Examination of Awareness, Knowledge, and Beliefs Regarding Radon

By

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Abstract

Problem: Radon exposure is the second leading cause of lung cancer after smoking and accounts for over 21,000 deaths in the US each year. The only way to know if radon is present is to test for it. Allentown, PA, with a 47% Hispanic population, has some of the highest levels of indoor radon in the world, yet only a small portion of the population has ever tested their homes. We hypothesized that there are factors unique to the Allentown population that are associated with this low testing rate. We also examined the role of health care providers in disseminating radon information.

Methods: Two cross-sectional studies were conducted in Allentown, PA. The first was a survey of 551 residents, which examined the relationship of awareness, knowledge, and beliefs about radon to ethnicity, primary language, age, income, homeownership, zip code, and education level. Testing and mitigation behaviors were also evaluated. The second cross-sectional survey of 40 health care providers was conducted to determine the level of communication about radon risk with their patients.

Results: In the first study, we found significant differences between radon awareness in relation to ethnicity, age, primary language, zip code, homeownership, education level and income. Overall, 64% of the population reported ever hearing of radon. Of those, 74% were non-Hispanic and 26% were Hispanic. Hispanics were less likely to have heard of radon even when controlling for other variables. In the second study, we found

that only 5% of the health care providers who were surveyed ever discussed radon with their patients.

Conclusion: These findings demonstrate a need for more effective and culturally appropriate communication strategies about radon risk that specifically target the Hispanic population. Also, health care providers (HCPs) have the potential to play an essential role in communicating the health risks of radon exposure. Professional medical associations can facilitate this by recommending that HCPs discuss environmental health risks with patients, especially in high-risk areas. Finally, there is a need for policies that require mandatory radon testing and mitigation in rental properties, schools, and daycare centers to protect citizens from harmful exposure to radon not only in Pennsylvania, but in the entire US.

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Preface

Everyone has a right to live in an environment free of health threatening environmental conditions. Low-income and ethnic minority individuals are much more likely than affluent whites to live in neighborhoods in which they are exposed to environmental hazards such as radioactive radon gas. In Allentown, PA, most Hispanics live in rental properties where they may unknowingly be exposed to dangerous levels of radon. Public Health practitioners need to work diligently to ensure that all Allentown residents understand the risk of radon exposure. Policy makers need to work to change building and housing codes so that radon inspections occur in all rental properties.

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This dissertation is dedicated to my parents

George Colitas

1924-2005

Dena Colitas

1921-2010

For always encouraging me

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CHAPTER 1: INTRODUCTION

1.1 Statement of Problem

Naturally occurring radon gas can become trapped inside homes and buildings, and rise to levels that are considered unsafe to human health. Exposure to radon is the second leading cause of lung cancer after smoking and accounts for over 21,000 deaths in the US annually.[1,2] Radon testing and mitigation are easy and efficient ways to significantly decrease high levels of radon in the home, thereby decreasing the incidence and prevalence of lung cancer. Scientists estimate that lung cancer deaths could be reduced by 2 to 4 percent by lowering radon levels in homes with radon levels greater than EPA recommended action levels.[3] There are no federal regulations requiring radon testing and mitigation, and state and local regulations are sporadic. Motivating residents to take action to test for radon and mitigate has proven to be challenging and communication programs regarding radon risk have been largely ineffective. The lack of effectiveness may be related to several factors. First, radon is an odorless, tasteless, colorless gas so exposure is not readily apparent. Also, exposure to high levels of radon is not ubiquitous so some people may assume that they are not at risk, even if they really are. Additionally, the health consequences of radon exposure are not immediately evident so people may not prioritize it as high risk. [4,5]

In Pennsylvania, this is especially true in Allentown, a city predominantly populated by Hispanics, although specific reasons for the failure to take action in comparison to their non-Hispanic counterparts are not entirely clear. A unique aspect of this study population is that they may have limited access to resources that provide

information regarding the risk of radon exposure in a language that they understand, or they may receive their information from sources other than the mainstream news, websites, and TV commercials where radon information is typically broadcast.[6] In addition, the current messaging regarding radon does not consider beliefs and attitudes unique to the Hispanic population when determining risk.[7] Therefore, I hypothesize that the disparity in radon testing rates between predominantly Hispanic neighborhoods compared to non-Hispanic neighborhoods is due, in part, to cultural and language barriers, in addition to the socioeconomic and education barriers encountered by both Hispanic and non-Hispanic people living in Allentown.

In addition to these barriers, the role of health care providers in communicating health risks to patients is vital. With limited time for each patient, physicians can often find it difficult to address issues pertinent to living in a healthy residential environment. In populations where language barriers exist, it can become even more difficult to cover these topics in a single appointment. This is problematic because patients rely on their physicians to provide information on health risks that would otherwise be unknown. I hypothesize that the reasons health care providers do not discuss radon with their patients is because their knowledge of radon may be lacking, they believe that radon exposure does not pose a significant risk to their patients, or they do not have time.

The purpose of this research was to 1) identify potential obstacles to radon testing within the Allentown Hispanic population and 2) identify obstacles encountered by health care practitioners in disseminating radon information to patients.

1.2 Specific Aim 1: Identification of obstacles to radon testing within the Allentown Hispanic Population

I conducted a cross-sectional pilot study of a sub-sample of Allentown residents using a face-to-face survey questionnaire that aimed to determine if there are obstacles unique to the Hispanic population that might influence the likelihood of testing and mitigating their homes for radon. Specifically, my research was structured to assess 1) the baseline knowledge, attitude, and perceived risk of radon exposure in the population, 2) potential obstacles to testing and mitigation, and 3) the association of social health determinants including socioeconomic status, education, ethnicity, language, and homeowner status with knowledge of radon exposure.

1.3 Specific Aim 2: Identification of obstacles to dissemination of radon information by pediatricians, family physicians, and other health care providers (HCPs) in the Lehigh Valley.

A 7-question survey of health care providers practicing in the Lehigh Valley was conducted electronically and in paper version to determine 1) their awareness of the risks of radon, 2) their communication strategies about radon risk, and 3) obstacles to discussing radon with their patients.

1.4 Allentown and the Greater Lehigh Valley

Allentown is geographically located in eastern Pennsylvania, 70 miles north of

Philadelphia, and 90 miles west of New York City, in an area known as the Lehigh Valley. With a population of 119,000, it is the third largest city in the state, and the largest city in the Valley, with over 47% of the Allentown population identifying themselves as Latino. The Lehigh Valley consists of two counties in Pennsylvania, is made up of 62 municipalities and 3 cities—Allentown, Bethlehem, and Easton—and has a population of approximately 659,000.[8] It is situated on a geological rock formation called the Reading Prong, which generates high levels of radon that can become trapped inside buildings such as homes and schools. Levels as high as 6,176 pCi/L (over 1,500 times higher than the EPA recommended level of 4 pCi/L) were detected in a residence located near Allentown, PA in November 2016.[9] These high levels are dangerous to human health but can be minimized with a fairly simple mitigation system installed in existing homes or with radon-resistant construction practices in new homes.

1.5 Organization of this Dissertation

This dissertation is organized into chapters including 1) Introduction, 2) Background and Literature, 3) Methods, 4) Results, and 5) Discussion. There are two Appendices. Appendix 1 is the survey questionnaire for Specific Aim 1. Appendix 2 is the survey questionnaire for Specific Aim 2.

CHAPTER 2: BACKGROUND AND LITERATURE

2.1 Hazard Identification and Routes of Exposure

Radon-222 is an odorless, colorless, tasteless, radioactive gas that naturally occurs from the decay of uranium-238, which is present throughout the earth's crust. Radon-222 has a half-life of 3.8 days and decays by the emission of alpha particles into radioisotopes called radon progeny, which include polonium, bismuth, and lead (Fig. 2.1). Though radon itself is exhaled rather quickly, the radon progeny tend to deposit on the bronchial epithelium, exposing cells to alpha radiation causing normal cells to transform into cancer cells.[10]

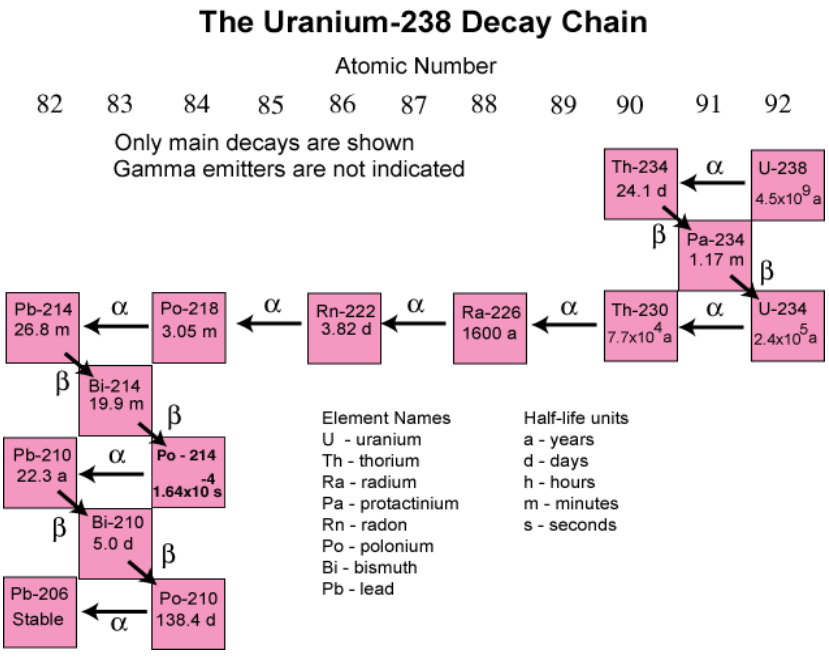

Fig. 2.1 shows the Uranium-238 Decay Chain including Radon and Radon progeny.[11]

Radon can be present in soil and water and can enter the home through either route. If ground water is used as the water supply, radon gas can be released while using water for showering or other household activities such as washing dishes, or ingested while drinking water.[12]

2.2 Health Effects of Exposure

Exposure to radon in the home is responsible for an estimated 21,000 lung cancer deaths each year in the US. About 2,900 of these deaths occur among people who have never smoked.[13] The risk of lung cancer increases with the amount of time spent in the home where levels are high. Smoking significantly increases the risk. A smoker exposed to radon is up to 20 times more likely to die from lung cancer compared to a non-smoker.[14]

The link between radon exposure and lung cancer is well documented, particularly in studies of miners. Epidemiological studies date back to the late 1800's when investigators first documented a high percentage of deaths from lung cancer in miners working in Europe, specifically in Germany and Czechoslovakia.[15] As uranium mining scaled up in the United States in the 1940's, the need for further study of the effects of airborne radiation on miners prompted the US Public Health Service (USPHS) to evaluate potential health problems indigenous to uranium miners. A USPHS study of uranium miners published in 1959 showed a statistically significant association between uranium mining and lung cancer for White miners.[16] Wagoner et al conducted a

longitudinal study of 3,656 white uranium miners in the Colorado Plateau of the United States, beginning in the mid 1950's and followed them until death. They found that a significantly larger percentage of miners died of lung cancer compared to that of the general male population of the Colorado Plateau even when controlling for other variables such as age and smoking status.[17] In 1965, Wagoner reported a 10-fold increase in lung cancer among long-term uranium miners.[15] The results of these and other early studies strongly suggested that a link existed between exposure to radon in the mines and increased risk of lung cancer. DeVilliers and Windish reported high relative frequency of respiratory cancer among miners of fluorspar who were exposed to high levels of radon progeny[18], and Saccomanno et al also demonstrated a higher incidence of lung cancer in uranium miners.[19] These data were consistent with early animal studies conducted in the 1950's on rats and dogs that showed an increase in pulmonary neoplasia in animals that were exposed to insoluble radioactive particulates. [20]

Subsequent studies on Navajo miners showed an increased risk of lung cancer due to radiation exposure. Gottlieb et al conducted a study on a small (n=16) group of Navajo miners diagnosed with lung cancer between 1965-1979. This population of Navajo miners smoked few cigarettes and had very low rates of lung cancer before uranium mining began in 1946. Their data showed that 62% of the miners with lung cancer had the same type of tumor as the white miners (undifferentiated small-cell tumors), which were largely attributable to radiation exposure.[21] Other investigators found similar results. Samet et al performed a matched case control study in Navajo men. They examined 32 cases of lung cancer in Navajo men (72% were previously

employed as uranium miners) between 1969 and 1982 and determined that when compared to controls who had not worked in the mines the relative risk was at least 14.4% more for those who had worked in the mines compared to those who had not. They concluded that most of the lung cancer was attributable to a single hazardous occupation, i.e. uranium mining.[22]

Data obtained from four principal studies of miners: the Ontario Uranium miners, the Saskatchewan Uranium miners, the Swedish metal miners, and the Colorado Plateau miners provided the basis for the BEIR IV report, (Biological Effects of Ionizing Radiation).[23] Pooled data from these four studies were used to develop a time-since-exposure risk projection model to determine excess relative risk of lung cancer mortality of underground miners exposed to radon in their occupational setting. Age at risk and time since cessation of exposure were considered significant factors modifying the excess relative risk of lung cancer mortality. Using this model, the committee determined that the lifetime risk of lung cancer death in males who had an occupational exposure level of 4 Working Level Months (WLM) per year from ages 20-40 was twice that of males in the general population. Assuming that the occupational results could be applied to radon exposures in houses, then lifetime exposure to 1 WLM/year was estimated to increase the number of deaths due to lung cancer by 1.5. The model was based on occupational exposure data and incomplete epidemiological data of the general population, and there were a number of uncertainties requiring assumptions concerning the factors that modify the carcinogenic risk of exposure to radon progeny. Most of the increased risk was determined to occur in smokers where the multiplicative effect of smoking and radon

exposure increased risk of lung cancer up to ten times compared to nonsmokers.[23]

The BEIR VI committee's report, which was published a decade after the BEIR IV report, was based on review of the four studies previously used in BEIR IV as well as seven additional epidemiological studies on miners.[24] Additionally, epidemiological studies of the general population and new information about the molecular and cellular basis of carcinogenesis by alpha particles were considered. Excess relative risk for lung cancer was calculated for ever smokers and never smokers. After a comprehensive analysis of the data, the committee concluded that there were 15,400 to 21,800 excess lung cancer cases in the US per year due to exposure to a combination of smoking and exposure to indoor radon, and that 2,100-2,900 of the 11,000 lung cancer deaths occurring in never smokers were due to radon. Their conclusions were based on two risk models that were used to extrapolate data from miners to general populations. These models, termed "the exposure-age-concentration" model and the "exposure-age-duration" model were framed in terms of excess relative risk representing the increase in lung cancer risk due to exposure to radon.[23]

The BEIR VI report acknowledged a number of assumptions and uncertainties associated with extrapolation of data from high exposures in the miners to lower residential exposures. For example, most of the evidence of miners is based on cumulative exposures at least 10 times higher than that of a typical lifelong residential exposure. Based on their most current understanding of the mechanisms of radon induced lung cancer, and the findings of the BEIR IV Committee, the BEIR VI committee adopted a linear no threshold (LNT) model in order to project risk. They

based their assumption on the mechanics of alpha particle carcinogenesis that shows that a single particle can cause a genomic mutation leading to irreparable repair and transformation of the cell. A mathematical model of the lung was also used to calculate doses to target cells received by miners and by the general population for a given exposure. [23]

Ongoing epidemiological studies continue to support the findings of the BEIR VI Committee. Krewski et al looked at pooled data of seven North American case control studies to determine the increased odds ratios for lung cancer due to residential radon exposure.[25] The investigators acknowledged that there are factors that complicate direct extrapolation of occupational data on radon lung cancer risk to residential settings. But, considering the known carcinogenesis of alpha particles and the greater statistical power of the pooled data, (n=3,662 cases; 4,966 controls) they determined that the estimated OR after exposure to radon in a time window of 5-30 years before diagnosis, at a concentration of 100 Bq/m^3 (approx.4 pCi/L) was 1.11 (CI1.0-1.28). This was compatible with the estimate of 1.12 (CI 1.02-1.25) predicted by downward extrapolation of the miner data. An analysis of 13 European case control studies done by Darby et al, found similar results.[26] In that analysis, data from a total of 7,148 people with lung cancer and 14,208 controls were analyzed and showed strong evidence of an association between residential radon and cancer. In addition, the dose-response relation appeared to be LNT. Overall, the results of the Darby et al European study were consistent with Krewski's North American study. Darby et al reported an 8% increase (3%-16%) per $100Bq/m^3$ in lung cancer risk compared to Krewski et al who reported an 11% increase.

Another pooled study combining data from two large case control studies (1,050 cases and 1,996 controls) on residential radon exposure in one urban and one rural area of China also showed statistically significant increases in excess risk in lung cancer as radon levels increased.[27] The pooled data analysis showed an excess odds ratio of 0.133 (0.01,0.36), which was consistent with the North American study and the European study, and with the extrapolation from miner data.

Perhaps one of the most comprehensive radon studies to date is the Iowa radon lung cancer study conducted by Field et al.[28] This case control study (413 cases; 614 controls) examined women age 40-84, both smokers and ever smokers who had lived in their current home for a minimum of 20 consecutive years. Demographic and historical data were collected from study participants by mail survey and also face-to-face interviews (or interviews of relatives if cases were deceased). Radon levels were measured for a year on every level of the home, in bedrooms and in-home work spaces. Outside measurements and measurements in other buildings where study participants spent significant time were also used to reconstruct individual radon exposure history. The results showed that a 15 year exposure to residential radon at levels equivalent to the EPA's action level of 4 pCi/L yielded an increase in lung cancer risk of 50% to as high as 83% after adjusting for age, smoking, and education.

Several ecological studies on radon exposure were conducted in the 1990's. Cohen et al[29] suggested that the risks for very low levels of radon had been overestimated and that very low levels might even be protective against lung cancer, but these claims were discounted by the BEIR VI committee based on methodological limitations,

(ecological studies have well-known limitations arising from the lack of individual dose estimates and information on possible confounding factors), and on subsequent study findings that refuted the ecological studies. A study by Thompson et al used methodology similar to the methods used in the Iowa study.[30] Thompson presented data from a matched case control study (200 cases; 397 controls) of lung cancer incidence and residential radon exposure in Worcester County, MA conducted over a ten-year period. In contrast to previous studies, this study showed evidence of a "possibility of a hormetic effect on lung cancer" for radon exposures less the 150 Bq/m^3. One of the major problems with this study was that the data showed very weak, if any, statistical significance. Based on larger and more statistically powerful studies like the North American, European, and Chinese studies which collectively include over 12,000 cases and 21,000 controls, and the Iowa study, all of which do not support hormesis, the EPA maintains its position of a linear no threshold dose-response relationship between residential radon exposure and lung cancer, and recommends voluntary testing for residential radon and mitigation for levels at or above 4 pCi/L.

2.3 Regulations and Recommendations Applicable to Exposure

The average indoor air level in the US is about 1.3 pCi/L and the average outdoor level is about 0.4 pCi/L. Pennsylvania (PA) has some of the highest reported levels of radon in the country, with 49 out of 67 counties in the state reporting levels higher than the EPA action level of 4pCi/L[31]. The EPA recommends radon mitigation if the radon level is 4 pCi/L or higher in air, or 4,000pCi/L or higher in water, although even levels

below this still pose a risk.[30] These levels are referred to as "action" levels meaning that current mitigation technology can almost always reduce radon levels to below these action levels. Testing is completely voluntary and residents may hire a tester or perform the test themselves. There are no federal, state, or local laws requiring the testing or mitigation of homes for radon. There are no laws in Pennsylvania regarding radon testing other than Department of Environmental Protection (DEP) certification requirements for all radon service providers, radon testers, radon mitigators, and radon labs.[32] There are no laws requiring PA schools to be tested for radon levels. There are no requirements that pediatricians address radon with their patients. In real estate transactions, there are no laws requiring a seller to test for radon, however, if radon levels have been tested, then the seller must disclose this information to the buyer. The buyer may request radon testing, but the seller is under no obligation to do so[33] and even if radon levels are high, the seller is under no legal obligation to mitigate, (although some studies have shown that mitigation rates increase when radon levels are disclosed during real estate transactions).[34] The EPA's new radon reduction new construction (RRNC) standards require builders to use radon protective materials, but to date only four states require builders to comply with the new code and Pennsylvania is not one of them, (with the exception of several local jurisdictions, including the city of Easton).[35] Presently, the only state law in Pennsylvania regarding radon is that all radon testers, testing labs, and mitigators must be certified by the state. [36]

2.4 Radon Testing and Mitigation

In order to determine how much radon gas has accumulated in the home, measurements of radon can be taken in several different ways. Homeowners can purchase short-term radon test kits, which remain in the home for 2-3 days. The EPA recommends these kits if results are needed quickly and should be followed up by a second short-term test. Long-term tests are used for more than 90 days and can be used to give a reading that indicates the home's year-round average radon level. Radon detectors are simply placed in multiple locations in the house, especially the lower levels and where residents spend the most time. If the water supply comes from ground water, the water can also be tested using a radon water detector. Once radon levels are determined, then the need for control measures can be recommended to the homeowner.

To minimize the amount of residential radon, professional mitigators can install a simple radon pump that vents the radon from the basement out through the roof. This procedure can be accomplished in as little as two hours and costs typically range between $700-$2,000 for a single family home. Even without a pump, sealing cracks in the home's foundation can impact the amount of radon gas seeping into the house and may be enough to decrease levels below 4pCi/L. Studies conducted to determine why testing and mitigation are not standard practice for homeowners, especially in areas where radon levels are known to exceed recommended levels have shown that lack of awareness of the problem, low perception of risk, and cost of testing and mitigation are the top reasons why people do not test and mitigate for radon. [37,38,39,40]

2.5 Challenges in Communicating Radon Risk

Communication that encourages voluntary testing for residential radon has not been particularly effective in motivating residents to test for radon. Strategies such as newspaper narratives, test kit giveaways, and distribution of door-to-door pamphlets have been largely unsuccessful. One of the first studies to examine public response to radon risk communication was conducted by Sandman and Weinstein in the late 1980s.[41] They analyzed the public reaction to naturally occurring radon in northern New Jersey (NJ). The NJ Department of Environmental Protection wanted all homeowners in the northern portion of the state to monitor for radon in their homes and if levels were above 4 pCi/L, to take remedial action. Surveys of residents in northern New Jersey were used to determine residents' knowledge of radon, emotional response to radon (e.g. concerned, angry, frightened), perception of radon risk, and relevant behavior to act if radon levels were above 4 pCi/L. The results showed that 65% of respondents answered factual questions about radon correctly. Respondents were moderately concerned and/or worried, but reported low fear, anger and helplessness. Over 50% of respondents thought that their own homes would have less radon than average, and 14.9% believed that a radon-caused illness would be serious. Only 6.6% of respondents had a radon test completed or in progress. The main reasons for not monitoring were that they did not think they were at risk; they were unsure what method was best and how to get tests carried out; and they had not yet found the time. [41]

Another study group conducted an experiment using newspaper stories to describe

the risk of radon exposure.[42] In one newspaper, a fictitious personal narrative was published describing an account of an individual's decision-making process regarding radon testing and remediation. In another newspaper, a technical piece presenting scientific facts about radon was published. When compared, the technical piece had slightly more of an impact than the narrative in enhancing awareness and concerns about radon, but neither strategy encouraged a significant increase in testing or mitigation.[42]

In another study, a mass-media radon campaign was tested in Washington, DC using a cooperative effort between a TV station, grocery store, and a radon testing company.[43] The grocery store offered radon test kits at half-price and the testing fees were waived. At the same time, the TV station ran a three part series called "Radon Watch". Over 100,000 test kits were sold and those whose test results were greater than 4pCi/L received EPA publications about radon. Those with levels over 20pCi/L were also sent an EPA publication about radon reduction methods. Just over half of those who purchased test kits returned them for analysis and of those whose radon levels were found to be above 4 pCi/L, less than one percent actually mitigated.[43]

A study by Johnson and Luken examined the perceived risk and mitigating behavior in Maine households who received an information pamphlet about significant health risks from indoor radon.[44] Scientists at the University of Maine at Orono developed the 11-page pamphlet consisting of illustrations, graphs and tables. It was sent along with radon test results and followed up by a subsequent telephone survey which asked respondents about their understanding of the information in the radon pamphlet, subjective and objective risk perceptions, mitigating actions and related cost. The

researchers found that respondents, even after indicating that the pamphlet was understandable, typically underestimated their risk (36.1% for medium and 55.5 % for high risk), and that only 51.1% did something to mitigate against radon exposure.[44]

Radon information, including health risks and remediation information, can be found on the US Environmental Protection Agency (EPA), state Department of Environmental Protection (DEP) and the American Lung Association (ALA) websites, yet only 10% of Pennsylvania households have reportedly been tested.[45,46,47] These results suggest that risk communicators have a difficult task to get homeowners to monitor for radon and mitigate their homes if the levels are high. They also suggest that while short term bursts of information might motivate some to respond, in general, this strategy is not particularly effective in evoking people to change their ideas and behaviors about radon testing and mitigation in the long term.

In order for risk communication to be effective, the message being sent, as well as the unique characteristics of the receivers of the message, must be considered. Current radon risk communication efforts fail to consider how risk is perceived in different ethnic populations. Risk communication is not a "one size fits all" process. Communicators need to consider and understand the attitudes, beliefs, language, culture, and limitations of the intended audience.

2.6 Hispanics and Radon

There has been very little intervention research directly examining the effects of considering culture when designing health campaigns that target culturally diverse

population subgroups and the IOM Report on Communication Strategies in Diverse Populations suggests that diversity and culture should be taken into account.[48] Hispanics are the fastest growing population in the US with 57 million representing 17% of the population as of September 2016. This number is expected to double by the year 2060. This population has grown more rapidly (337%) than the total US population (41.9%) and accounted for the net population growth in the US.[49,50]

The Hispanic population in Allentown is the majority population (47.4%) and consists mainly of Puerto Ricans (25.1%), Dominicans (7.9%), and Mexicans (2.1%) with other subgroups making up the difference. Allentown City is divided into five major zip codes (Fig.2.2), 18101, 18102, 18103, 18104, and 18109. Differences exist among the zip codes, especially in regards to the proportion of Hispanics living in housing rentals, annual income, percent of people who rent, and the number of radon tests completed (Table 2.1).

Zip Code Zones in Allentown, PA

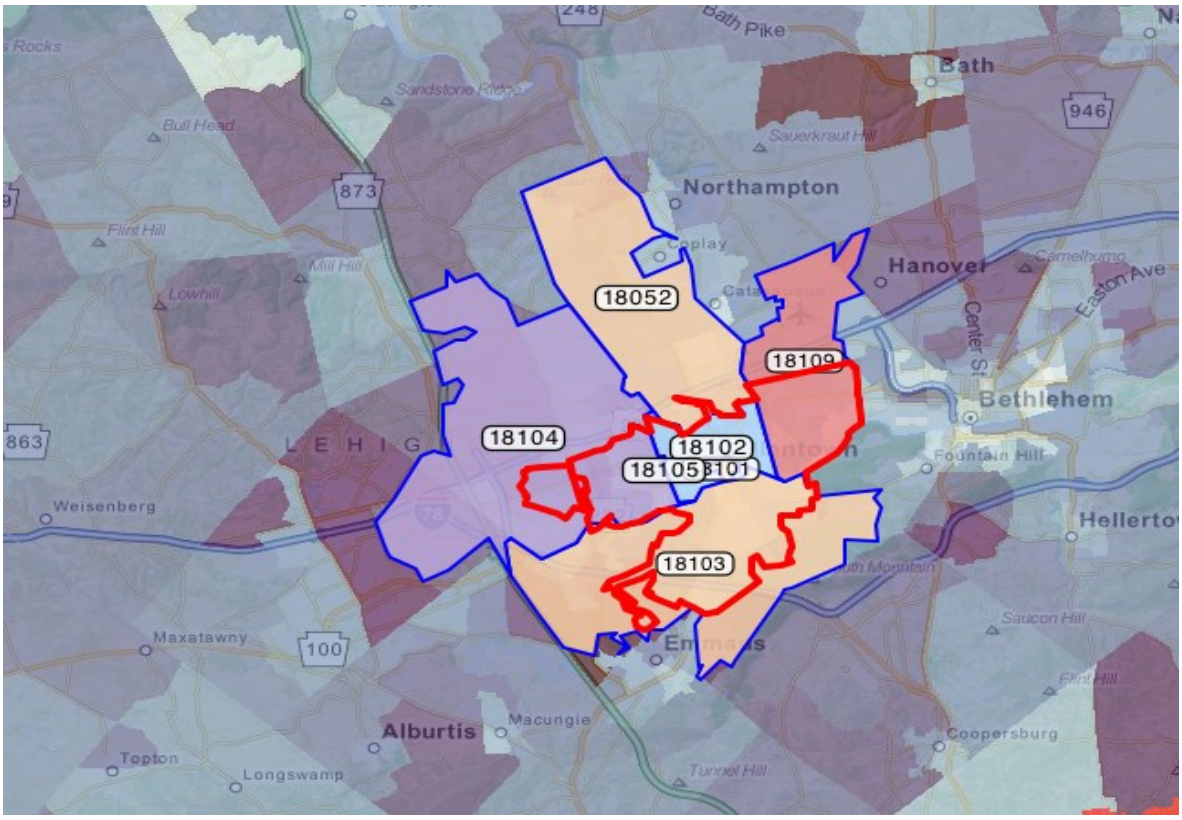

Fig.2.2. Map of Allentown, PA zip codes.[51]

Table 2.1 Demographic and Radon Testing Information in the Main Allentown Zip Codes

Zip Code	% Total Population	% Hispanic	Est. Household Annual Income	% Renters	No. radon tests on file with state (% total household)	Total no. houses/ condos in zip code	Maximum radon test result pCi/L	Average Radon Level pCi/L
18101	2%	60	$17,250	92	43 (2.7)	1,792	19.5	4.2
18102	30%	57	$26,575	65	658 (3.5)	18,764	44.7	5.2
18103	30%	28	$48,289	32	2,626 (14)	18,874	178.6	6.9
18104	27%	0.76	$67,929	26	4,095 (23)	17,641	217.7	6.7
18109	11%	37%	$33,035	47	250 (3.5)	7,040	13.1	6.0

Demographic data[50] Radon data[52]

Pennsylvania Department of Environmental Protection data show that there is much less radon testing occurring in Allentown zip codes where Hispanics are the majority population compared to zip codes with mostly non-Hispanic populations.[51] This is alarming, because the average levels of radon in these areas are above the 4 piC/L action level set forth by the EPA. Not surprisingly, previous studies support the data in Table 2.1 and show that minority populations of lower socioeconomic status are typically at greatest risk for adverse health effects and adverse health conditions associated with poor air quality.[53]

Failure to test for radon may be related to lack of awareness of the problem. Radon risk information is not easily accessible to anyone, but it may be especially challenging for people with communication limitations such as language barriers and access to technology. Currently, a number of things need to happen in order for people to become informed about radon; 1) they need to be aware of radon, 2) they need to have access to a computer to investigate radon, 3) they need to know what websites to visit to learn more about radon, and 4) the website information needs to be written in a language they understand. IOM's recommendation for better health communication programs for diverse populations includes messages that are not only written in Spanish, but also take into consideration reading levels and cultural appropriateness.[61]

The aim of this research is to address the IOM's plea, specifically by determining the obstacles and limitations associated with obtaining radon information, and crafting ways to effectively communicate the risk of radon to the Allentown Hispanic community.

2.7 Hispanics and Lung Cancer

The National Cancer Institute cites cancer as the leading cause of death among Hispanics, accounting for 21% of deaths overall and 15% of deaths in children.[54] Overall, about 1 in 2 Hispanic men and 1 in 3 Hispanic women will be diagnosed with cancer in their lifetime. The lifetime probability of dying from cancer is 1 in 5 for Hispanic men and 1 in 6 for Hispanic women. Among Hispanic men, lung cancer is the leading cause of cancer death, and the second leading cause of cancer death for Hispanic women. According to the SEER report, the incidence of lung cancer is nearly twice as high in white men (68.1) and women (51.8) per 100,000 compared to Hispanic men (36.6) and women (32.0). The lower incidence of lung cancer among Hispanics is probably due to the lower prevalence of smoking in Hispanics (13%) compared to whites (21%).[54] It is important to note that data reported for Hispanics as an aggregate group may mask true values because Hispanics vary greatly with respect to country of origin, immigration status, socioeconomic status, acculturation and other cultural factors. Lung cancer death rates within Hispanic subpopulations vary due to these differences, particularly in smoking patterns. For example, Cuban men in the US have historically had the highest prevalence for smoking and have 30% higher lung cancer death rates when compared to Mexican or Puerto Rican men.[55] In Pennsylvania, lung cancer incidence is 67.1/100,000, which is slightly higher than the Lehigh County incidence of 64/100,000. Both are higher than the US incidence of 63.7/100,000.[56] Although EPA formally recognized radon as an environmental hazard in the 1980s, it is not standard practice for physicians to list radon exposure as a cause of lung cancer. For this reason, there are no available data on the

number of lung cancer cases in Allentown specifically attributable to radon exposure.

2.8 Culturally Sensitive Risk Communication

Recent consensus in public health and health communication reflects increasing recognition of the important role of culture as a factor associated with health and health behaviors. [57,58] Culture, as defined by social scientists is "learned, shared, transmitted intergenerationally, and reflected in a group's values, beliefs, norms, practices, patterns of communication, familial roles, and other social regularities".[59] Communication approaches that need to be considered when designing and evaluating health communication and behavior change efforts may need to be different in the Hispanic population than in a non-Hispanic population. The literature suggests risk communication may be more effective in the Hispanic population, generally speaking, if the role of family, cultural traditions, collectivism, acculturation, language, and generation are considered. Perceptions of stigmatization and discrimination from the community, and variation within the Hispanic community with respect to immigration and socioeconomic status also need consideration when designing risk messages.[60] An Institute of Medicine (IOM) report on communication strategies for diverse populations suggests that concordance between the cultural characteristics of a given group and the public health approaches used to reach its members may enhance receptivity, acceptance, and salience of health information and programs. The IOM report states that there is an "urgent need" for studies assessing the relative effectiveness of different strategies of addressing diversity in communication campaign programs. Two of the specific types of research identified in the IOM report to help meet this need are 1) evaluations of new and ongoing

communication programs in ways that assure appropriate data are collected to allow for subgroup analyses that can be linked to diversity strategies employed in the programs, and 2) field tests in which communication programs using alternative diversity strategies are compared among equivalent groups.[61]

Research regarding environmental health issues and the Hispanic community is sparse. The novelty of this dissertation is that it considers radon knowledge, attitudes, and beliefs about radon as an environmental health risk in a large Hispanic population. I also consider the association between ethnicity and social determinants such as socio-economic status, education level, primary language, zip code, and homeowner status with the likelihood of knowing about radon risk. Based on my review of the literature to date, this has not been previously studied. The results of this preliminary research may be used to determine if there is a need for further exploration regarding the role that ethnicity plays in radon testing behavior. We can also examine whether innovative education and communication strategies are needed so that radon information is disseminated appropriately for this study population. In addition, the results can be used to promote policy changes regarding radon testing and mitigation practices.

2.9 Health Care Providers and Radon Education

The second aim of the proposed research is also novel in that there is currently limited data regarding physicians' attitudes and beliefs regarding radon risk and whether they discuss the potential health consequences of radon exposure with their patients. A study of pediatricians conducted in Georgia[62] showed that the majority of respondents

reported that while they felt that environmental health discussions with patients were important, they did not feel equipped to have those conversations. Respondents reported low self-efficacy regarding environmental history-taking, discussing environmental exposures with parents, and finding diagnosis and treatment resources related to environmental exposures. The probability of self-reported history taking varied with the specific exposure, with environmental tobacco smoke and pets most frequently queried and asbestos, mercury, formaldehyde, and radon rarely queried.[62] Another study survey of New York pediatricians[63] found that the majority of respondents reported high self-efficacy when dealing with lead, but very low self-efficacy with dealing with other environmental health hazards such as pesticides, mercury, and mold. The results of our survey of health care providers in the Lehigh Valley can offer insight on ways we might utilize this very important communication channel to get information to patients about the dangers of radon.

Chapter 3: Methods

3.1 Data Collection

We conducted a cross-sectional study of residents (n=551) in Allentown, PA from March 2017 to May 2017 referred to as Survey Questionnaire 1 in this document (Appendix 1). Residents who were at least 18 years of age and resided in an Allentown, PA zip code were eligible to participate. A 29-question anonymous survey questionnaire was used to acquire data in face-to-face interviews. The survey was translated into Spanish by a certified translator. The six interviewers were bilingual (3 non-Hispanic females, 1 Hispanic female; 2 Hispanic males) and the interviews were conducted in either English or Spanish as needed. In order to maintain consistency and minimize interview bias, all interviewers received the same training in how to conduct the interviews prior to the start of the research. Responses were recorded by interviewers on iPads using Qualtrics© Survey Software and then uploaded to a main data repository. Surveys were conducted at various locations throughout the City of Allentown and included six grocery stores, five churches, a neighborhood tree-planting event to celebrate Earth Day, and an immigration information session. Survey participation was voluntary and an oral informed consent was obtained from study participants prior to starting the survey. Once the survey was completed, each survey participant was compensated with $5 cash and was given a pamphlet that included information about radon, testing and mitigation, and links to the Pennsylvania Department of Health and the EPA. The Institutional Review Board at Johns Hopkins School of Medicine approved the research protocol.

A second cross-sectional survey of health care providers in Allentown, Bethlehem and Easton was conducted using a 7-question survey tool referred to as Survey Questionnaire 2 in this document (Appendix 2). The survey was initially emailed to all pediatric and family practices in these three cities. An informed consent document was included. Response rate was poor using this survey method, so we continued using a paper version of the survey that was dropped off in the offices and picked up at a later date. The Institutional Review Board at Muhlenberg College approved the research proposal.

3.2 Survey Questionnaire 1

Prior to beginning this research, a pilot of the survey questionnaire was tested at a local supermarket with a small cohort (n=25) and some questions were modified as deemed necessary prior to data collection for this study.

The final survey questionnaire (Appendix 1) was designed to obtain information regarding awareness, knowledge, perceived susceptibility, and barriers regarding radon and radon testing and mitigation. The questionnaire was also used to obtain socio-demographic information as well as participants' smoking histories, source(s) of medical information, and number of doctor visits per year.

We used the National Health Interview Survey (NHIS)[63] and the National Health and Nutrition Examination Survey (NHANES)[64] demographic questions, and radon surveys previously described in the literature[65,66,67,68,69]to design the questions regarding radon on our survey. The survey was designed to investigate whether there are

differences between Hispanics and non-Hispanics regarding awareness, knowledge, and concern regarding radon and to determine if other variables including age, income level, education level, zip code, homeowner status, and primary language influence awareness of radon. In addition, there were survey questions regarding health behaviors including smoking status, number of annual visits to a health care provider, and sources of health information. The survey questions are summarized below.

Awareness and knowledge of radon (Questions 1-4)

Participants were first asked if they had "ever heard of radon". If they answered "no" they then skipped the radon-related questions and moved directly to the demographic portion of the survey, beginning with Question 11. If they answered "yes", then they moved on to a series of follow up questions (Questions 2-10) regarding radon.

The second question asked them "where have you heard of radon" in order to determine which communication channels might be useful (or not useful) for disseminating radon information. For this question, interviewers read a list of possibilities and participants were asked to select any and all answers that applied. If they wished to add other communication sources that were not included on the selection list, they were able to do so using a text box.

For question 3, the interviewer read four statements about radon and asked participants to tell us if they thought the statements were true or false. The statements included, "It is an invisible gas that can become trapped inside your home"; "There is nothing that can be done to remove radon from your home"; " You live in an area where

indoor radon levels are typically very high"; and "Breathing in radon gas can cause lung cancer".

Awareness and concern about health problems associated with radon (Questions 4-5)

Because perceived susceptibility, (i.e., one's perception of the chances of health problems associated with exposure to radon), may be a motivator to test one's residence, we asked two questions about awareness and concern in regards to radon-related health problems and followed up with a question about whether or not the current residence had been tested for radon. Question #4 asked, "How *aware* are you of the health problems that can be associated with high radon levels in your home?" and the possible answers were "not aware of any associated health problems", "somewhat aware of associated health problems", and "fully aware of associated health problems". The follow-up question #5, asked, "How *concerned* are you about the health problems cause by radon exposure?" and the possible answers were "not concerned", "somewhat concerned" and very concerned".

Testing and mitigation for radon (Questions 6-10)

The sixth question asked, "Have you or someone else ever tested your current residence for radon"? If respondents answered "no" or " I don't know", to Question #6, then they moved on to Question #10, which asked them to indicate the reason(s) why they did not test their residence for radon. There was a list of reasons to choose from including "Do not know how to test for radon", "Do not believe that radon is a health

threat to you or your family", "Testing is too expensive", "Do not own your own home", "There is already a radon pump in your house", "Don't know" or "other" where a text box could be filled in with an answer. All answers that applied could be chosen for this question.

If the respondents answered "yes" to Question #6 (i.e., that they had tested their homes for radon), then they moved on to question #7 which asked if the "radon level in your home was found to be higher than recommended". If the answer was "no", then respondents skipped to the demographic questions. If the answer was "yes", then they moved on to Question #8 which asked, "have you or someone else paid to install a radon pump in your home"? If the respondent answered "yes" then they moved on to the demographic questions. If they answered "no", then they moved on to a Question #9 which asked "why a radon pump was not installed". Respondents could select any and all answers that applied, including "too expensive", "do not know how to have a radon pump installed", "do not own your own home", "do not believe that radon is a health threat to your or to your family", "found other ways to take care of the problem", "there already was a pump installed when you moved in", or "other" where respondents could use a text box to fill in an answer.

Demographics **(Questions #11-22)**

The questionnaire was used to obtain socio-demographic information, specifically ethnicity (Hispanic vs. Non-Hispanic), primary language, zip code, and home owner status, education level, and annual income level.

Health and Medical information (Questions #23-29)

Question 23 asked participants to select the (one) channel they most recently used to look for information regarding health topics. They were given a list to choose from that included their doctor, the internet, newspaper, magazine, family, friends, TV, radio, church, books, brochures or some other channel that could be typed into a text box.

Questions 24-26 were smoking status questions. Participants were asked if they were ever, never, or current smokers and also if they lived with smokers.

We asked participants how many times they had visited a doctor or other health care professional in the past 12 months (question 27). Questions 28 and 29 asked whether a doctor or other health care professional had ever discussed the health effects of lead exposure with them.

3.3 Survey Questionnaire 2

The short healthcare provider survey questionnaire contained seven questions (Appendix 2). These questions assessed whether healthcare providers (HCPs) addressed radon in any way during patient visits, and what reasons they had for not discussing it. In addition, we asked if HCPs would be agreeable to providing accessible information about radon in their waiting rooms, e.g. in videos on brochures. Finally, we asked if they routinely discuss the risk of lead exposure with patients in order to determine the likelihood of any environmental health risk being discussed in a patient visit.

3.4 Statistical Analysis

Both descriptive analyses and logistic regression were used to examine the data. For categorical data, counts and percentages are presented. Pearson's chi square analysis was used to determine p-values and statistical significance set at 0.05. Binary logistic regressions are summarized using odds ratios and 95% confidence intervals. SPSS 21.0 (SPSS Inc., Chicago, IL) was used for data analysis.

Chapter 4 Results

4.1 Demographics of the Sample Population

The frequency distribution of characteristics of the sample population compared to the general Allentown population, and the statistical significance (p value) calculated by chi-square analysis, are shown in Table 4.1. The total sample size was 551 with 53% male respondents (n=293) and 47% female respondents (n=258). The largest age group was 51-65 (n=174; 32%), followed by over 65 (n=141; 26%) and 36-50 (n=146; 26%), and 18-35 (n=90; 16%). Ethnicity in the sample was 57% Non-Hispanic (n=313) and 43% Hispanic (n=238). Nearly double the number of respondents reported English as their primary language (n=342; 62%) compared to those who reported Spanish as their primary language (n=188; 34%). More respondents were homeowners (n=331; 60%) than renters (n=220; 40%). Only 2% (n=8) of respondents lived in the 18101 zip code, 30% (n=165) in the 18102 zip code, 24% (n=134) in the 18103 zip code, 19% (n=103) in the 18104 zip code and 19% (n=103) in 18109. Most of the respondents had either attended college (n=206; 37%), or had graduated from high school (n=194; 35%), 16% (n=86) had advanced degrees and 12% (n=65) did not graduate from high school. Most had annual household incomes between $25,000-49,999 (n=148; 27%) followed by $50,000-74,999 (n=99; 18%), more than $75,000 (n=99; 18%) and less than $10,000 (n=60; 11%). In comparison to the demographics of the general Allentown population, education levels were statistically significant for high school graduates, ($p<0.001$), 2-4 year college, ($p<0.001$) and graduate school, ($p<0.001$). There was no significant difference in the less than high school groups ($p=0.06$).

Table 4.1 Demographic Characteristics of Pilot Study Population in Allentown, PA

		Sample (N=551) % (N)	Allentown[51] (N=119,104) % (N)	P value
Gender	Female Male	47 (258) 53 (293)	52 (62,279) 48 (56,825)	0.48 0.48
Age*	18-35 36-50 51-65 Over 65	16 (90) 26 (146) 32 (174) 26 (141)	------- ------- ------- -------	
Ethnicity	Non-Hispanic Hispanic	57 (313) 43 (238)	53 (62,942) 47 (56,162)	0.32 0.32
Primary Language	English Spanish Other	62(342) 34(188) 4(21)	47 (56,000) 44 (52,000) 8 (9,528)	<0.05 0.14 0.23
Zip Code^^	18101 18102 18103 18104 18109 Other	2 (8) 30 (165) 24 (134) 19 (103) 19 (103) 6 (37)	2 (4013) 30 (48, 617) 30 (48,163) 27 (43,641) 11 (17,264)	1.0 1.0 0.33 0.17 0.07
Type of Housing	Rent Own	40 (220) 60 (331)	52 (61,934) 48 (57,170)	0.09 0.09
Total Annual Income+	Less than $10,000 $10,000-24,999 $25,000-49,999 $50,000-74,999 $75,000 or more Refused	11 (60) 14 (79) 27 (148) 18 (99) 18 (99) 12 (66)	------- ------- ------- ------- -------	
Education Level&	Less than HS HS Graduate 2-4 year college Graduate School	12 (65) 35 (194) 37 (206) 16 (86)	22 (26,202) 58 (69,080) 16 (19,056) 4 (4,764)	0.06 <0.001 <0.001 <0.05

*Median Age (Allentown)= 32.7; +Median income (Allentown) $36,655; &Allentown data available only for 25 years and older . ^^Allentown zip code population includes city and suburbs= 161,698. Chi-square analysis was used to determine statistical significance (p values <0.05).

Table 4.2 shows a comparison of demographic characteristics between Hispanic and non-

Hispanic respondents. When the numbers of respondents were categorized by gender, chi-square analysis showed no statistically significant difference between the number of Hispanic males and non-Hispanic males ($p=0.11$) and between Hispanic females compared to the number of non-Hispanic females ($p=0.11$) in the sample population. There was not a statistically significant difference in age 18-35 years between Hispanics and non-Hispanics ($p=0.08$) or in age 51-65 years ($p=0.76$). There were statistically significant differences in age 36-50 years ($p<0.001$) and in over 65 years (($p<0.001$). There were more Hispanics age 36-50 (38%) than non-Hispanics (17%). In over 65 years there were 8% Hispanics and 40% non-Hispanic. There was a statistically significant difference in primary language between Hispanics and non-Hispanics ($p<0.001$), with Hispanics speaking primarily Spanish (80%) and non-Hispanics speaking primarily English (99%). The number of Hispanic respondents was not significantly different from the number of non-Hispanic respondents in the 18101 ($p=0.56$) or the 18109 zip codes ($p=0.19$), however they were statistically significant differences in the 18102, (37% Hispanic vs. 24% non-Hispanic), 18103, (33% Hispanic vs. 18% non-Hispanic) and 18104, (7% Hispanic vs. 28% non-Hispanic) zip codes all with p values <0.05. There was a statistically significant difference in homeownership (i.e. renters vs. owners) between Hispanics and non-Hispanics ($p<0.05$), with Hispanics more likely to be renters. There were no statistically significant differences between Hispanics and non-Hispanics in the total annual income categories except for the $75,000 or more range ($p<0.001$) with 7% of Hispanics in that range compared to 30% non-Hispanics. Education levels were statistically significantly higher in the less than high school (HS) level group with 21%

Hispanics in this group compared to 5% non-Hispanics ($p<001$) and also in the graduate school group with 4% Hispanics and 24% non-Hispanics ($p<0.001$). The high school graduate group ($p=0.14$) and the 2-4 year college group ($p=0.38$) did not show statistical significance between Hispanics and non-Hispanics.

Table 4.2 Comparison of Demographic Characteristics between Hispanic and Non-Hispanic Respondents

		% Hispanic (N=238)	%Non-Hispanic (N=313)	P-Value
Gender	Female	47	58	0.11
	Male	53	42	0.11
Age	18-35	21	12	0.08
	36-50	38	17	<0.001
	51-65	33	31	0.76
	Over 65	8	40	<0.001
Primary Language	English	20	99	<0.001
	Spanish	80	1	<0.001
Zip Code	18101	2	1	0.56
	18102	37	24	<0.05
	18103	33	18	<0.05
	18104	7	28	<0.001
	18109	21	29	0.19
Type of Housing	Rent	49	33	<0.05
	Own	51	67	<0.05
Total Annual Income	Less than $10,000	17	9	0.09
	$10,000-24,999	22	12	0.06
	$25,000-49,999	38	25	<0.05
	$50,000-74,999	16	24	0.16
	$75,000 or more	7	30	<0.001
Education Level	Less than HS	21	5	<0.001
	HS Graduate	41	31	0.14
	2-4 year college	34	40	0.38
	Graduate School	4	24	<0.001

* Hispanic vs. Non-Hispanic using Chi-Square analysis (statistical significance at $p<0.05$)

4.2 Radon Awareness in the Sample Population

Of the sample population (N=551) surveyed, 353 respondents (64%) had ever heard of radon. Fifty-five percent (n=161) of the males surveyed and 74% (n=192) of the females surveyed had heard of radon. There was not a statistically significant difference ($p=0.36$) between the percentage of males and females who had ever heard of radon.

Thirty-one percent (n=28) of the 18-35 year olds surveyed had ever heard of radon, 53% (n=78) of the 36-50 year age group, 70% (n=122) of the 51-65 year age group, and 89% (n=126) of the over 65 year group had ever heard of radon ($p<0.05$).

Thirty-nine percent (n=92) of the total Hispanics surveyed and 83% (n=261) of non-Hispanics ($p<0.05$) had heard of radon, 81% (n=278) of primary English speakers and 40% (n=75) whose primary language was Spanish ($p<0.05$) had heard of radon.

Of the eight residents of the 18101 zip code surveyed, 38% (n=3) had ever heard of radon, 44% (n=73) in the 18102, 62% (n=83) in the 18103, 91% (n=94) in the 18104, and 77% (n=79) in the 18109 ($p<0.05$). In addition, 39% (n=85) were renters and 81% (n=268) were owners of their homes ($p<0.001$).

Thirty-one percent (n=21) of total respondents with annual incomes less than $10,000, 44% (n=35) in the $10,000-24,999 income level, 61% (n=90) in the $25,000-49,999, 82% (n=81) in the $50,000-74,999 income level, and 94% (n=93) in the over $75,000 income level ($p<0.05$) had ever heard of radon.

For education level, there were 35% (n=23) of the respondents in the less than high school group who had heard of radon, 55% (n=106) of the high school graduate group, 70% (n=145) of the 2-4 college group, and 92% (n=79) in the graduate school

group ($p<0.001$).

The 353 people who had ever heard of radon were categorized by gender, ethnicity, primary language, zip code, type of housing, total annual income and education level. The percentage of Hispanics who had ever heard of radon compared to the percentage of non-Hispanics who had ever heard of radon in each category is shown in Table 4.3. For these results, the denominator used was the total number of Hispanics or non- Hispanics in each category. For example, there were 126 male Hispanics who took the survey and of those, 49 (39%) had ever heard of radon compared to 131 non-Hispanic males who took the survey of which 112 (85%) had ever heard of radon. The data show that for all demographic groups, the percent of Non-Hispanics who had ever heard of radon is significantly higher than the percent of Hispanics ($P<0.05$) except in the "less than high school" education groups. Only 39% of the Hispanic males reported ever hearing about radon compared to 85% of the non-Hispanic. Of the 112 Hispanic females, 38% had heard of radon compared to 82% of the 182 non-Hispanic females.

Only 18% of the Hispanics (n=50) in the 18-35 year age group had heard of radon compared to 50 % (n=38) in the non-Hispanic group ($p<0.001$), and 42% of Hispanics in the 36-50 age group (n=90) compared to 75% of non-Hispanics (n=53) ($p<0.001$) had ever heard of radon. In the 51-65 year age group, 48% (n=79) of Hispanics and 86% (n=97) of non-Hispanics ($p<0.001$), and in the over 65 age group 37% (n=19) of Hispanics and 95% (n=125) of non-Hispanics had ever heard of radon ($p<0.001$).

There were no Hispanics in the 18101 zip code who had heard of radon (n=5) compared to 38% (n=3) of non-Hispanics ($p<0.001$), 28% of Hispanics (n=88) compared

to 64% of non-Hispanics (n=75) in the 18102 zip code had heard of radon ($p<0.001$), 41% of Hispanics (n=78) and 89% of non-Hispanics (n=56) in the 18103 zip code had heard of radon ($p<0.001$), 53% of Hispanics (n=17) and 93% (n=88) of non-Hispanics in the 18104 zip code ($p<0.001$), and in the 18109 zip code 24% (n=19) of Hispanics and 73% (n=58) had heard of radon ($p<0.001$).

Of the Hispanics who were renters, (n=117), 23% had ever heard of radon compared to 56% of non-Hispanic renters (n=103) ($p<0.001$), and 55% of Hispanic homeowners (n=121) had heard of radon compared to 96% of non-Hispanic homeowners (n=210) ($p<0.001$).

Income levels were also statistically significant. Of the Hispanics who reported earning less than $10,000 per year (n=40), 25% had heard of radon compared to 39% of non-Hispanic (n=28) ($p<0.05$). In the $10,000-24,999 income group, 29% of Hispanics (n=52) and 53% of non-Hispanics (n=38) had heard of radon ($p<0.001$), 33% Hispanics (n=90) and 77% non-Hispanics (n=78) had heard of radon in the $25,000-49,999 group ($p<0.001$), 47% of Hispanics (n=38) and 84% of non-Hispanics (n=75) in the $50,000-74,999 had heard of radon ($p<0.001$), and 65% of Hispanics (n=17) and 87% of non-Hispanics (n=94) in the $75,000 or more group had heard of radon ($p<0.001$).

There were 32% of Hispanics (n=50) and 44% of non-Hispanics (n=16) with less than a high school level education ($p=0.08$), and 33% of Hispanics (n=97) and 76% of non-Hispanics (n=97) who were high school graduates ($p<0.001$) who had ever heard of radon. 48% of Hispanics (n=81) and 85% of non-Hispanics (n=125) with college level education ($p<0.001$) had heard of radon, and 50% of Hispanics (n=10) and 99% (n=75)

of non-Hispanics ($p<0.001$) who had attended graduate school who had ever heard of radon.

Table 4.3 Radon Awareness by Sociodemographic Characteristics

		% Hispanic* (n=92)	%Non-Hispanic^ (n=261)	P Value
Gender	Male	39	85	<0.001
	Female	38	82	<0.001
Age	18-35	18	50	<0.001
	36-50	42	75	<0.001
	51-65	48	86	<0.001
	Over 65	37	95	<0.001
Language	English	42	83	<0.001
	Spanish	39	0	<0.001
Zip Code	18101	0	38	<0.001
	18102	28	64	<0.001
	18103	41	89	<0.001
	18104	53	93	<0.001
	18109	24	73	<0.001
Type of Housing	Renter	23	56	<0.001
	Owner	55	96	<0.001
Income[+]	Less than $10,000	25	39	<0.05
	$10,000-24,999	29	53	<0.001
	$25,000-49,999	33	77	<0.001
	$50,000-74,999	47	84	<0.001
	$75,000 or more	65	87	<0.001
Education Level	Less than HS	32	44	0.08
	HS Graduate	33	76	<0.001
	2-4 year college	48	85	<0.001
	Graduate School	50	99	<0.001

*Of those respondents identifying as Hispanic. ^Of those respondents identifying as non-Hispanic.
+Those who refused (n=33) to answer this question were not included in the analysis.
P values determined by chi-square analysis between Hispanics and Non-Hispanics with significance ($p<0.05$).

A binary logistic regression model was used to determine if the demographic characteristics were independent predictors of radon awareness. The results are shown in Table 4.4. The model demonstrated that age (OR=2.14, [1.67-2.74]), education level (OR 2.08 [1.55-2.78]), ethnicity (OR .235 [.149-.372]), and housing (OR=4.36 [2.73-6.96]) were associated with radon awareness at a statistically significant level. The association between total annual income and radon awareness (OR=1.01, [.897-1.137]) was not statistically significant.

Table 4.4 Associations between Sociodemographic Characteristics and Radon Awareness

Variable	B	SE	Sig	OR	95% CI
Age[1]	.762	.127	<0.001	2.14	(1.67,2.74)
Education Level[2]	.733	.150	<0.001	2.08	(1.55,2.78)
Ethnicity[3]	-1.446	.233	<0.001	.235	(.149, .372)
Housing[4]	1.473	.239	<0.001	4.364	(2.73,6.96)
Income[5]	.010	.060	.871	1.01	(.897,1.137)

Model was adjusted for age, education level, ethnicity, housing, and income.
[1]Reference group = 18-35; [2]Reference= group less than HS; [3]Reference group= Hispanic; [4]Reference group= Renters; [5]Reference group = less than $50,000

4.3 Sources of Radon Information

The most commonly reported sources of information about radon are shown in Table 4.5. Of those who answered that they had ever heard of radon, (n=353), the most commonly reported sources of information were TV commercials (31%), newspapers/magazines (30%), realtors (26%), TV news programs (28%), and family/friends (23%). The least commonly reported sources of information were doctor (5%)), radio news programs (10%), radio commercials (11%) and the Internet (11%). Sources that were not included on the survey list of possible answers, but were most commonly mentioned by respondents as "other" included school (3%), work (6%) and hardware stores (<1%).

Table 4.5 Sources of Radon Information by Ethnicity

Channels	Total Number (N=353) N (%)	% of Hispanics (N=92) N (%)	% of Non-Hispanics (N=261) N (%)	P value
TV commercial	108 (31)	35 (38)	73 (28)	0.13
Radio commercial	40 (11)	6 (7)	34 (13)	<0.001
TV news	100 (28)	17 (18)	82 (31)	<0.05
Radio news	37 (10)	7 (7)	30 (11)	0.32
Newspaper/magazine	105 (30)	3 (3)	101 (38)	<0.001
Internet	40 (11)	4 (4)	36 (14)	<0.05
Doctor	19 (5)	2 (2)	17 (7)	0.08
Family/Friend	81 (23)	16 (17)	65 (25)	0.16
Realtor	93 (26)	19 (21)	74 (28)	0.24
Other*	62 (18)	17 (18)	45 (17)	0.85

Note: Respondents could select more than one answer so percentages do not add up to 100%. *Other included School (N=12), Work (N=21) and hardware stores (N=2). Chi-square analysis used to calculate statistical significance ($p<0.05$) between Hispanics and non-Hispanics.

For respondents identifying themselves as Hispanic, the highest percentage of responses for sources of information about radon were TV commercials (38%), Realtor (21%), Family/Friend (17%), Radio news (19%), TV news (17%), radio commercials (15%), and other sources (27%). They were least likely to select the doctor (2%), newspaper/magazine (3%), Internet (4%), or radio commercials (7%). For respondents identifying themselves as Non-Hispanic, the highest percentages of responses for sources of information were newspaper/magazine (38%), TV news (31%), a realtor (28%) , TV commercials (28%), and Family/Friends (25%). The least likely were the doctor (7%), radio news (11%), radio commercials (13%), and the Internet (14%). Non-Hispanics were significantly more likely than non-Hispanics to get their radon information from radio commercials ($p<0.001$), TV news, ($p<0.05$), Newspapers/magazines ($p<0.001$) and the Internet ($p<0.05$).

4.4 Radon Knowledge, Awareness, and Concern

The total number of respondents who had heard of radon was 353 (64% of the total sample population). Of those who had heard of radon, 92 (26%) identified as Hispanic and 261 (74%) identified as Non-Hispanic ($p<0.001$). When asked to identify four statements regarding radon as either true or false, 82% of Hispanics and 97% of non-Hispanics correctly selected the true statement “It is an invisible gas that can become trapped inside your home”($p<0.001$); 13% of Hispanics and 49% of non-Hispanics selected the true statement “You live in an area where indoor radon levels are typically very high”($p<0.001$); and 75% of Hispanics and 77% of non-Hispanics selected the true

statement “Breathing in radon gas can cause lung cancer”(p=0.74); 14% of Hispanics and 4% of non-Hispanics (incorrectly) selected the false statement, “There is nothing that can be done to remove radon from your home” as being true (p<0.001).

Participants’ responses to the question regarding the level of awareness of the health problems associated with radon were “Not Aware” (32% Hispanic; 18% Non-Hispanic, p<.01), “Somewhat Aware” (38% Hispanic; 51% Non-Hispanic, p<0.05) and “Fully Aware” (30% Hispanic; 31% Non-Hispanic, p=0.88). When asked about the level of concern regarding the health problems associated with radon, responses were “Not Concerned” (20% Hispanic; 17% Non-Hispanic, p=0.58), “Somewhat Concerned” (39% Hispanic; 49% Non-Hispanic, p=0.15) and “Very Concerned” (41% Hispanic; 34% Non-Hispanic, p=0. 31).

4.5 Radon Testing and Mitigation Practices

Respondents that indicated that they had ever heard of radon (N=353), were asked a series of questions regarding testing and mitigation. Table 4.6 shows that of the 92 Hispanics that indicated that they had ever heard of radon, 29 (32%) said their homes had been tested, 60 (65%) had not tested, and 3 (3%) did not know if their home had ever been tested. Of the 261 non-Hispanics, 113 (43%) said that their home had been tested, 123 (47%) had not ever tested, and 25 (10%) did not know (p<0.05). For those who had tested their homes, 2/29 (7%) of Hispanics, and 36/113 (32%) of non-Hispanics found the levels to be higher than EPA recommended levels, 24/29 (83%) of Hispanics and 66/113 of non-Hispanics did not find higher than recommended levels, and 3/29 (10%) of Hispanics and 11/113 (9%) of non-Hispanics did not know what the radon test

results showed ($p<0.05$). Of the Hispanics who found high levels of radon in their homes 2/2 (100%) had a radon pump installed and 28/36 (78%) of non-Hispanics had a radon pump installed ($p=.66$).

Table 4.6 Radon Testing and Mitigation Practices

	Hispanic N (%)	Non-Hispanic N (%)	Total N (%)	P value
Q6. Have you or someone else ever tested your current residence for radon?*				
Yes	29 (32)	113 (43)	142 (40)	<0.05
No	60 (65)	123 (47)	183 (52)	
I don't know	3 (3)	25 (10)	28 (8)	
Q7. If yes, was the level found to be higher than recommended?^				
Yes	2 (7)	36 (32)	38 (27)	<0.05
No	24 (83)	66 (58)	90 (63)	
I don't know	3 (10)	11 (9)	14 (10)	
Q8. If yes, was a radon pump installed in your residence?+				
Yes	2(100)	28 (78)	30 (79)	0.66
No	0 (0)	8 (22)	8 (21)	

*Of total number (353) of respondents answering that they had ever heard of radon (Hispanic N= 92; non-Hispanic N=261); ^Of the total number of respondents answering yes to Q6; (Hispanic N= 29; non-Hispanic N= 113; total N=142) +Of the total number of respondents answering yes to Q7 (Hispanic N=2; non-Hispanic N=36; total N=38). P values calculated for statistical significance ($p<0.05$) between Hispanic and non-Hispanic using chi-square analysis.

4.6 Obstacles to Radon Testing

Those study participants who responded that they had heard of radon (n=353) and that they had never tested their homes or that they don't know if their homes have ever been tested (n=211; 60%) were asked to indicate reasons why they did not test. Table 4.7 shows the five most common responses.

Table 4.7 Most Common Reasons for Failure to Test for Radon

Reason	Hispanic N=63 N (%)	Non-Hispanic N=148 N (%)	Percentage of total number* N=211 N (%)	P value
Don't know how to test	21(33)	22 (15)	45 (21)	<0.05
I don't own my own home	14 (22)	26 (18)	40 (19)	0.73
Don't believe radon is a health threat	10 (16)	27 (18)	37 (18)	0.70
Too expensive to test	4 (6)	17 (11)	21 (10)	0.20
Already have a radon pump	2 (3)	2 (1)	4 (2)	0.31
Other responses	5 (8)	35 (24)	13 (7)	<0.05

*Respondents could choose all that applied and/or add their own response so numbers do not add up to 100% (N=183). "Other" answers with <2 respondents were not reported.

The most commonly selected choice was “Don’t know how to test for radon (21%), followed by “I don’t own my own home” (19%), “I don’t believe radon is a health threat” (18%), “It is too expensive to test (10%) and “I already have a radon pump in my home” (4%). Other responses not listed in the table were “I don’t have a basement (2%), “I just moved in” (2%), “I would have already gotten sick” (3%), I don’t want to know (1%), “I don’t know why” (1%), I don’t live in the basement (<1%) , “I haven’t gotten around to it (<1%) and “I can’t move anyway” (<1%).

4.7 Obstacles to Radon Mitigation

Of the total number of respondents who tested their homes and found the radon level to be high (n=38), 30 (79%) installed a radon pump. Eight of them (all non-Hispanic; 21%) did not install a radon pump. When asked why they did not install a radon pump, 2 people said it was too expensive, 2 people did not believe radon is a health threat, 1 person did not know how to install a radon pump, 1 person already had a pump, 1 said there was no time, and 1 did not live in the basement so did not feel the need to install a pump.

4.8 Health Behaviors

The percentage of the total sample population (N=551) who reported that they were current smokers was 14% (n=76), 31% (n=170) reported that they ever smoked at least 100 cigarettes in their life, and 16% (n=87) live with a smoker. In the Hispanic sample population (N=238), 12% (n=27) were current smokers, 24% (n=56) ever

smoked, and 15% (n=36) lived with a smoker. In the non-Hispanic sample population (N=313), 16% (n=49) were current smokers, 36% (n=113) ever smoked, and 16% (n=50) lived with a smoker. There was no statistical significance ($p>0.05$) in any group.

The percentage of the total sample population (N=551) who reported that they had never visited a health care provider (HCP) in the past 12 months was 9% (n=48), 23% (n=124 had seen an HCP once, and 68% (n=377) had seen an HCP more than once. In the sample Hispanic population (N=228), 10% (n=24) had never seen an HCP, 26% (n=63) had seen an HCP once, and 64% had seen and HCP more than once. In the non-Hispanic sample population (N=331), 7% (n=23) had never seen an HCP, 20% (n=16) had seen an HCP once, and 73% (n=226) had seen an HCP more than once. There was no statistical significance ($p>0.05$) between the number of Hispanics and non-Hispanics in any groups.

Respondents were asked where they most recently looked for health information. In the total sample population (N=551), 44% (n=241) of the respondents answered that they looked on the Internet and 30% (n=156) asked their health care provider. In the Hispanic sample population (n=238), 37% (n=88) looked on the Internet first and 31% (n=71) asked a health care provider. In the non-Hispanic population, 49% (n=153) used the Internet first and 27% (n=85) asked a health care provider. There was no statistical significance between Hispanics and non-Hispanics and the total population ($p>0.05$).

4.9 Dissemination of Radon Information by Health Care Providers

Results of the health care provider survey which included physicians, registered nurses, and physicians' assistants showed that only 2 of the 40 surveyed "sometimes" talked to their patients about radon. Thirty-eight HCPs said that they "Never" mentioned radon. None of the HCP's had any visible information in their offices (e.g. brochures or pamphlets, wall posters). When asked the reason why they did not discuss radon with their patients, 55% (n=22) said because they are not required to do so, 35% (n=14) said they had limited knowledge about radon, 8% (n=3) said they did not believe radon was a health risk, 53% (n=21) said they did not have enough time or resources to discuss radon with their patients, and 5% (n=2) said that they did not want to alarm their patients.

When the HCP's were asked if they informed their patients about lead exposure, 30% (n=12) said "Always", 38% said "Sometimes", and 35% said "Never".

Chapter 5 Discussion

5.1 Introduction

Radon gas is the second leading cause of lung cancer after smoking and poses a significant health threat to thousands in the US each year.[1,2,13,14] Since the 1980's, the US Environmental Protection Agency has recommended that residents test their homes and ground water for radon and mitigate if levels are found to be higher than the action levels. It is estimated that 1 out of every 15 homes in the US has elevated radon levels. [70] In Pennsylvania, all counties average higher than recommended levels, but the highest level of home radon ever recorded in the United States was in Lehigh County. Radon problems can be relatively easy to detect and fix, but individuals need to be aware of its seriousness in order to take action to determine if they have a problem. While multiple studies that have looked at awareness, knowledge, and belief about perceived risk of radon exposure in the literature, there is a dearth of knowledge regarding radon awareness specifically among Hispanics. The present research described a cross-sectional pilot survey of residents of Allentown, PA, located in Lehigh County to identify obstacles to radon awareness and home radon testing. A unique demographic characteristic of the Allentown population is that the majority population in Allentown is Hispanic (47%). Prior data revealed that Allentown zip codes predominately populated by Hispanics showed less home radon tests on file with the Pennsylvania Department of Health. Based on this data, I hypothesized that 1) there is a significant difference between Hispanics and non-Hispanics in their awareness of radon, 2) other variables that are associated with awareness of radon include age, education levels, income levels, primary language, zip

code, and home owner status, 3) there are differences between Hispanics and non-Hispanics in their perceived risk associated with radon exposure, and 4) health care providers may be missing out on opportunities to inform Allentown residents about radon exposure risk. While it is important to emphasize that no causal associations can be concluded with this type of study, it nevertheless provides us with information about the possibility of associations.

5.2 Association between Radon Awareness and Sociodemographic Factors

The survey results showed several notable associations between radon awareness and sociodemographic characteristics. Of the 238 Hispanics who completed the survey, 39% had ever heard of radon compared to 85% of non-Hispanic respondents (Table 4.3). This result supports the first hypothesis that there is a significant difference in radon awareness between Hispanics and non-Hispanics in Allentown, which could potentially explain why there was less radon testing occurring in geographical areas predominantly inhabited by Hispanics. This idea is supported by previous research examining radon awareness for African Americans, which showed that minority populations were much less likely to have heard of radon and much less likely to test their homes for radon than the rest of the population.[71] Several surveys and experiments that have been conducted to assess public perception of radon show a general lack of awareness about radon, but most research has focused on white populations.[40-42,44-47,73-74]

When we examined other variables besides ethnicity that may be contributing to the discrepancy in radon awareness between Hispanics and non-Hispanics, including age,

home ownership status, income level, education level, primary language, and zip code we found that there was a statistically significant association between each variable and the likelihood that a person had ever heard of radon regardless of ethnicity, however the proportion of Hispanics who had heard of radon in each group was significantly lower than non-Hispanics.

Age groups were significantly different in radon awareness, with respondents in age groups over fifty more likely to answer that they had heard of radon compared to respondents in age groups under 50. This may be due in part to our finding that people over 50 years old were more likely to be homeowners (67%) than people under 50 years so they may have heard of radon through real estate transactions. Homeowners were more likely to be non-Hispanic (67%) compared to Hispanic (51%). In our survey, 80% of homeowners who had heard of radon reported that they had heard of radon from a realtor. These data match previous work by Sandman and Weinstein that showed that nearly all radon testers are homeowners who, as a group, are higher income and education than the population average.[72] In Pennsylvania, a radon test disclosure statement is present on all real estate transactions. This type of information not only raises awareness about the problem, but also informs the buyer of potential health risks associated with the home purchase. In addition, if a mitigation system has been installed, the disclosure alerts the buyer to make sure the system is working properly before moving into the home. While it is not a requirement to have the home tested for radon prior to sale, radon levels, if the seller knows them, must be disclosed to the buyer. If they are not known, the buyer has the option of requesting an independent test prior to the

purchase of the home.

A key determinant of home ownership is socioeconomic status, and we found that survey respondents who earned annual incomes less than $50,000 were more than twice as likely to be renters compared to those who earned greater than $50,000 annually. Our survey showed a significant difference in radon awareness for respondents in annual income level groups below $50,000, and one of the reasons for this may be related to never negotiating a home sale. Respondents who lived in the 18101 and 18102 zip codes, (those with the least amount of radon tests on file with the state), were over twice as likely to report annual incomes less than $50,000 and three times as likely to be renters compared to those who lived in the 18103, 18104, and 18109 zip codes. The zip code in which a respondent resided did show a significant difference in radon awareness. Residents who lived in the 18103, 18104, and 18109 zip codes were significantly more likely to have heard of radon than those in 18101 and 18102. Additionally, the 18101 and 18102 zip codes had the highest percentage of respondents with a high school education level or less. These results parallel other research that shows that in the US, non-White and low SES individuals are more likely to be exposed to health-threatening environmental conditions such as hazardous waste, air and water pollution, and indoor air pollutants including radon.[73,74] Income is often directly related to environmental quality. An earlier study conducted in rural New York counties by Chi and Laquatra (1990) suggested that radon exposure was related to income levels. Their data showed that 66% of rentals and 41% of owner occupied homes that were occupied by individuals whose annual income was less than $40,000 had radon levels above EPA safe limits, compared

to 36% of owner occupied homes with income levels greater than $40,000.[75] This is probably related to more affordable homes for those below the poverty line that may have structural deficiencies such as gaps between basement walls or large cracks in the foundation thus allowing radon to enter more easily. [76]

It is difficult to untangle the relationship between ethnicity, income, homeownership and zip code with radon awareness in this study because there is overlap among these variables. To suggest that radon awareness is associated with any one without consideration of the others would be difficult.

5.3 Knowledge and Concern About Radon Exposure

In order to test knowledge of radon, we asked respondents to answer four true/false questions about radon. Nearly all of the respondents, who had heard of radon, knew that it was an invisible gas and that there was something that could be done about it, and that breathing in radon gas could cause lung cancer. However, less than 40% of total respondents knew that they lived in an area where indoor radon levels are typically very high. Although there were significant differences between the proportion of Hispanics and non-Hispanics who answered the questions correctly, this trend was the same for both Hispanics and non-Hispanics. The majority of respondents who indicated that they had ever heard of radon considered themselves at least somewhat aware of the health problems associated with high levels of radon (78%) and reported that these health problems were concerning to them (82%), and yet only 40% reported ever testing their current residence. There is no guarantee that even if an individual is fully aware,

knowledgeable, and concerned about the health risks associated with radon exposure, that testing and mitigation will occur. In fact, multiple studies have shown that increased awareness and concern have not led to levels of testing and mitigation that would typically be expected. Studies by Sandman, Weinstein, and Klotz [77,78] and Johnson and Luken[79] found that the most common response to radon to be one of apathy and disinterest. The reason for this remains a mystery, however, there are several possible hypotheses regarding this, mostly related to the fact that radon has many characteristics that typically lead people to underestimate the risk. These include the idea that the risk of lung cancer from radon exposure is relatively low; there are no perceptual clues to alert people of its presence (such as taste, color, odor); radon is naturally occurring and therefore, inevitable; the risk is not the same for everyone as some homes have high levels and some do not; and, radon-induced lung cancer takes many years to develop and displays no early symptoms.[80]

When we asked our survey participants why they had not tested their homes for radon, the most common responses were 1) they didn't know how to test, 2) they didn't own their own home, 3) they didn't believe radon was a health threat, and 4) the test is too expensive. A significantly smaller percentage of Hispanics (32%) had ever tested their homes compared to non-Hispanics (43%), but the reasons for not testing were similar between both groups with statistical significance only between the Hispanics and non-Hispanics who said they did not know how to test. Sandman and Weinstein found similar results for not testing in their studies of New Jersey residents.[81] In their studies, they examined the association between awareness of radon and testing among New

Jersey residents. They found that knowledge and awareness of radon was a good predictor of thinking about testing, but did not necessarily result in actual testing of one's home. They describe a behavior stage model, termed "precaution-adoption process model for radon testing" that addresses a phenomenon where individuals are aware of radon and may even decide to test, but never actually carry out the test. Individuals, they argue, move through a number of stages beginning with awareness of radon but never thinking about testing, thinking about testing, deciding to test, and actually carrying out a test. Moving through each stage is dependent on variables that may apply only to a single stage. Their study results showed that the perceived likelihood of a radon problem in one's home was highly correlated with deciding to test but did not necessarily lead to testing and that many people who go so far as to purchase test kits may not actually conduct the test or send the kits back for analysis. [81]

For the 142 respondents who tested their homes, only 38 reported that the radon level was found to be higher than recommended, and of those, 30 had a radon pump installed. There was no significant difference between Hispanics and non-Hispanics regarding the installation of the pump. This mitigation rate, 79%, is high and supports the findings of a previous study by Weinstein et al[82] who reported mitigation rates for a sample of 123 New Jersey homeowners to be 62%, but contradicts a study by Doyle et al[79] that shows a mitigation rate range of 11.9%-52.5% depending on detected radon levels.

5.4 Health Care Providers and Radon

Given that a health care provider seems to be a reasonable channel for radon risk communication, we asked respondents how many times they had visited a health care provider over the previous 12 months. There were no significant differences between Hispanics and non-Hispanics. In fact, 20% of the total population reported that they had been to a health care provider at least once and 73% reported that they had been more than once. Only 5% of the sample population who had ever heard of radon reported that they had heard about it from their doctor.

In regard to this previous finding, we ran a concurrent study of health care providers in the Lehigh Valley to determine what percentage were discussing radon risk with their patients. We specifically targeted pediatric practices and family practices because we felt that most people were likely to come into contact with at least one of these in their lifetime. Our results were disappointing but not surprising. One of our biggest challenges was that we were unable to get many health care providers to take our survey. Of those who did take the survey, only 2 (out of 40) said that they sometimes discuss radon with patients. Many stated that they just did not have enough time during an appointment to discuss radon, and others said that they either were not aware of a radon problem, or that they did not feel equipped to discuss it with their patients. Medical schools do an inadequate job of teaching students about environmental health risks.[83] This is unfortunate given the likelihood of an environmental health risk contributing to disease and death. Physicians in the Lehigh Valley need to be aware of the radon problem and should be providing their patients with information about it. Given the

previous survey results that showed that a majority of the sample population gets their health information from their health care provider, it seems that this is a missed opportunity to disseminate information that may save lives.

If radon discussion with patients became part of standard practice, then awareness might increase, possibly leading to increased testing. Despite this idea, physicians in our sample regard radon as low risk and it may take further study, physician training, and consumer demand to shift the level of current attitudes and practices.

5.5 Smoking Status and Radon

We examined the relationship between smoking status and ever hearing of radon because smokers are at greater risk from the harmful effects of radon as are the members of their households and prior research results show that smoking status is one of the best predictors of radon concern---non-smokers are more likely to show concern about radon risk than smokers.[84] Our smoker population was 14% (n=77) of the total sample population, and of those, only half (7% of the sample population) had ever heard of radon. Approximately 16% (n=88) of the sample reported living with smokers and only half of those (8% of the total population) had ever heard of radon. In total, 30% of the sample population report tobacco smoke exposure and only half are aware of radon. This raises some public health concerns given that the synergistic effect of smoking and radon is well documented.[85] Smokers or people who live with smokers who are not aware of the health risks associated with radon, or who are not aware of or able to test and mitigate for it, are at increased risk of developing lung cancer. Smokers have up to 20 times the risk of developing lung cancer when exposed to high levels of radon compared to smokers

who are not.

5.6 Radon Communication

Most respondents who had heard about radon said that they had heard about it from a realtor, TV news, or the newspaper. There was a significant difference between the sources where Hispanics said they had heard of radon and where non-Hispanics had heard of radon (Table 4.5). Hispanics were more likely to hear about radon from a realtor, family/friend, or from a TV commercial, and non-Hispanics were more likely to have read about it in the newspaper or heard about it on the TV news. Interestingly, very few in either group reported hearing about radon from their health care provider. This information may prove to be very useful when designing messages for the Hispanic population. Hispanics may not receive current messages that are in the newspaper or in the news as frequently as non-Hispanics do and alternative channels and sources of information should be considered.

In an attempt to determine the most utilized channels of health communication in the sample population, we asked respondents to indicate where they first looked for health-related information the most recent time they needed it. In the total sample population, and in both the Hispanic and non-Hispanic populations, the most popular answer was the Internet followed closely by their health care provider with 76% of respondents selecting either one of these.

Based on the survey results regarding radon awareness, current radon risk communication programs are not as effective in reaching a Hispanic target audience

compared to a non-Hispanic audience even when similar channels of communication are used. This finding parallels past research on radon awareness and reduction campaigns for African Americans, which has shown that many public outreach campaigns fail to communicate radon information effectively to lower-income and minority populations[86,87] By understanding the cultural characteristics of Hispanics, risk communication programs can be customized to better meet their needs.

Addressing cultural sensitivity and cultural appropriateness are complex. While the concept of cultural sensitivity is not new to public health, there is wide variation in the use of the term. Social scientists agree that culture is "learned, shared, transmitted intergenerationally", and is reflected in a group's "values, beliefs, norms, practices and patterns of communication, familial roles, and other social regularities." [88] There are many variables that contribute to Hispanic culture, most notably country of origin, language, and generational status. The extreme cultural diversity among Hispanics in the US, in addition to diversity in socioeconomic status and acculturation (i.e. the shift in attitudes and beliefs from one's culture of origin to another) makes it challenging to design health communication programs that reach everyone. There are not many examples of health communication and health promotion programs that specifically address or build upon the cultural characteristics of the Hispanic population. Health promotion programs for diabetes and cancer screening, for example, have been moderately successful but there are significant gaps in the literature regarding the role of culture in health communication.[6-7] Researchers at the Moffitt Institute in south Florida have successfully developed health education and support programs to address health

disparities in the Hispanic community. [89] For example, the Yo me cuido® program promotes breast cancer screening in Hispanic women, and their Language Services department addresses language barriers for patients who are not English proficient. These programs have been nationally recognized and serve as examples of the type of health programs that are needed to serve the Hispanic population. At the very least, it seems that messages that are in Spanish, as well as English, might be a good place to start. Messages that consider only language, but not literacy levels or socio-economic status will most likely not be effective. These messages should be sent through appropriate channels that are the most likely to reach a Hispanic audience. This might include the Internet and Spanish TV stations according to our study results. For example, the telenovela, a Spanish language version of a TV soap opera, is a popular form of entertainment in many Hispanic households and has been shown to be an effective channel for providing information on breast cancer.[6] This channel may prove to be effective for providing information on other health risks like radon. In addition, Allentown community health agencies could explore using lay community health care workers (known in Spanish as "promotoras"), who have been effective in educating the Hispanic population about other health issues such as asthma, maternal and infant care, and nutrition to educate the population about radon.[88]

The role of the Internet cannot be understated. The overwhelming majority of our study respondents looked for health information on the Internet before any other communication channel, including their health care provider. Information about radon on the Internet should be easily visible, displayed often, and presented in creative and

innovative ways. In Allentown, journalists who covered the story of the house in Center Valley with a radon level of over 6,000 pCi/L in November 2016 should continue to write articles for the Internet, newspaper, and TV news, so that people don't forget. The information should also be in the Spanish newspapers, on Spanish TV news, and in TV commercials during Spanish TV programming since the majority of our Hispanic sample population said they had heard of radon from a TV commercial. Additionally, though we did not specifically ask about it in our survey, social media such as Twitter, Facebook, Instagram, and SnapChat should be considered as channels of communication. It is estimated that 81% of people in the US have a social media profile.[90] A Pew Research Center report on social media usage released in 2015 showed that 90% of 18-29 year olds tended to have at least one social media account, while the likelihood decreased for respondents in older age groups. The report also showed that of those respondents who used the Internet, 75% Hispanics, 70% non-Hispanic Whites, and 67% non-Hispanic Blacks used Facebook, and 28% Hispanics, 20% non-Hispanic Whites and 28% non-Hispanic Blacks used Twitter.[91] Our findings showed that respondents in the 18-25 year old age group were the least likely to have heard of radon, suggesting that social media might be a useful communication tool for this cohort. In addition, given the high percentage of Hispanics who use social media, especially Facebook, it may be worthwhile to explore this channel as a strategy for disseminating information about radon.

Not only do communication programs need to focus on awareness, but they must also emphasize the importance of testing and mitigating. The majority of the study respondents did not realize that they lived in an area with very high radon levels. Messages should be more forthcoming about the link between radon and lung cancer so

that people understand the risk. More explicit messages are needed to explain the home testing process, such as where to purchase or obtain the test kits, how to use them, where to send them, and what to do with the results. More specific information about testing procedures, and more access to free testing kits may encourage more homeowners to test. Although follow-up with mitigation is not a guarantee, this may prove to be more effective in motivating residents to test rather than simply telling them they should test. In addition, renters belong to a subpopulation that needs to be specifically targeted with messaging, as our data suggest that even when they have heard of radon, they feel powerless to do anything about it. Given that the Hispanics that we surveyed made up the majority of the renters in Allentown, it is important to design messages that reach them on multiple levels so that they are not only aware of the risk, but also are guided on measures that can be taken to minimize or eliminate it.

Finally, health care providers play a vital role in providing information to patients about environmental risks that are unique to a specific residential locale. In both surveys, we found that while health care providers could play a key role in increasing radon awareness, they don't. In the survey of the sample population, nearly a majority indicated that they depend on their health care provider for health information, yet only 5% of the sample population who had ever heard of radon had heard about it from their HCP. When we surveyed health care providers only 2 out of 40 indicated that they sometimes discuss radon with their patients. These are missed opportunities for HCP's to inform their patients about the deadly effects of radon exposure especially among smokers. Our findings are consistent with previous research that showed that physicians

do not routinely discuss radon or other environmental health risks with their patients.[62-63]

5.7 Strengths and Limitations of the Research

There are several limitations to this research. First, the cross-sectional design of this study makes it impossible to identify causal relationships between the tested variables and radon awareness. Even though we identified several factors as potentially contributing to awareness, they may not be conclusive. In addition, there may be variables that we did not consider that are influencing the direction of association. Also, we did not specifically ask respondents if they have a lower level, or how much time they spend in the lower levels of their homes where radon is most likely to accumulate. Though this would not directly impact the results of the survey, we would not be able to determine if the people we surveyed were at any increased risk of exposure to high doses because of the level of the home on which they resided. This is especially true for renters. Second, we were likely underpowered to detect differences for some variables, particularly in the 18101 zip code and education level, and in regards to why people who have high levels of radon in their homes don't install radon pumps. Third, the low response rate for Survey 2 (health care providers) compromised the power to adequately detect significant effects. Additionally, for both surveys, we may have encountered interview bias causing respondents to give us the answers that they thought we wanted to hear. Also, recall bias may have been a factor and that resulted in misclassification of some respondents. Finally, it is important to mention that we have grouped all Hispanics as a single homogenous group. We realize that extraordinary diversity exists among

subgroups of Hispanics and, as such, limits our conclusions about our study sample. For this pilot study, we opted to categorize Hispanics without stratifying for specific country of origin to determine if there were any differences between individuals who identified as Hispanic compared to those who identified as non-Hispanic. Now that we have identified a significant difference in awareness based on ethnicity, a next step would be to determine if country of origin among Hispanics reveals significant differences in the study outcomes.

The strength of this research is that we conducted the surveys face-to-face with a representative sample of Hispanics and non-Hispanics. This also allowed us to ensure that we could get completed surveys with all questions answered. Our sample population was sufficiently large enough to estimate the prevalence of radon awareness. Also, by varying our survey locations, we were able to better match the demographics of our sample population with the study population, making our sample population representative of the larger Allentown population. Another major strength is that no research heretofore has examined the relationship between ethnicity and radon awareness. We hope the results of this study will begin to expand our conversation among the major stakeholder agencies in Allentown to formulate reasonable solutions and policies to address the problem of radon, particularly for the Hispanic population.

5.8 Implications of the Research on Policy Changes

In the 1980's, the Environmental Protection Agency acknowledged the carcinogenic effects of radon after a careful and thorough review of toxicological and

epidemiological data that repeatedly showed strong evidence that exposure to radon levels above 4 pCi/L in air and 4,000 pCi/L in water posed a significant threat to human health, specifically the development of lung cancer. This "action" level was deemed to be the level at which mitigation of radon should take place in order to minimize this risk. This recommendation by the EPA fell short of becoming a regulation and, therefore, there are no federal laws requiring that any building, including schools, homes and businesses, be tested for radon. And so, over 21,000 lung cancer deaths in the US — approximately 3,000 occurring in never smokers--- are attributable to radon that may have been prevented by requiring a simple radon testing and mitigation process.[92] These are more deaths per year than are individually attributable to drowning, falls, fires, homicide, and prescription opioid overdoses.[93] This is not to minimize the other causes of death, but it does raise the question as to why we don't hear about radon as often as some of these other causes of death in the news or why our lawmakers are not rushing to make policies regarding radon exposure or declaring public health emergencies about the problem.

In November 2015, the EPA and American Lung Association, in collaboration with two other federal departments and eight national organizations unveiled a new National Radon Action Plan.[94] The goals are to reduce the number of deaths caused by radon and reduce radon risk in 5 million homes.[95] Building on the Federal Radon Action Plan of 2011, the NRAP refined the framework for planning action by providing incentives and support for radon risk reduction. This includes strategies to ensure radon is a priority risk addressed in healthy homes programs. It also includes securing direct

support from philanthropic sources and the government to reduce radon risk for low-income Americans in homes, schools and childcare centers.[94]

Some states do have some radon related policies that aim to minimize the threat of radon. Currently, four states—Colorado, Connecticut, Florida, and Virginia—require radon testing in schools. Connecticut, Florida, Iowa, New Jersey, and Rhode Island all require radon testing in child care centers. These states, however, do not require mitigation if radon levels are found to be elevated. West Virginia and Rhode Island require mitigation in schools. Idaho, Maryland, and Michigan require mitigation in childcare centers, and New Hampshire requires mitigation in state buildings.[96] Some states have laws in place that require radon resistant new construction (RRNC). These laws require that new homes and buildings be constructed using radon resistant materials and techniques. There are currently three states that require RRNC in schools—Connecticut, New Jersey, and Rhode Island—and four states that require RRNC in homes—New Jersey, Michigan, Washington, and Minnesota.[91] Most states have laws that require certification of installers of radon mitigation systems. Pennsylvania requires that all radon testers, testing labs, and mitigators must be state certified.[39] There are no states that have laws that require homes to be tested for radon during a real estate transaction, although many states have radon disclosure laws. These laws require the seller to disclose any known radon levels or testing results. If they have never tested their property for the presence of radon, then the burden of testing and/or mitigating falls on the buyer. As of March 1, 2014 Maine requires the testing for and disclosure of radon levels in rental properties (excluding short term rentals of less than 100 days).[97] In Illinois, the law

requires landlords to disclose known elevated radon levels. Florida law requires that all rental agreements include a notification regarding the health risks of radon.[98] In our study 80% of homeowners had heard of radon from their realtor. Renters are at a disadvantage unless they have heard of radon from some other source. In our sample population, 15% of the people who had heard of radon were renters compared to 85% of those who were homeowners. Also, in our study population, the majority of renters, 52%, are Hispanic. The EPA does have on their website A Radon Guide for Tenants.[99] This guide includes information about funding available to reduce radon levels in rental housing, such as community development block grants from HUD; a 203K program that funds repairs on single family homes; and environmental justice grants from community based organizations that address environmental concerns of people of color and low income communities. Some states such as Maryland, have governmental programs that can provide loans for radon reduction work in limited housing.[98]

Environmental hazards in rental properties are not recent issues and exposure to environmental hazards in the US occurs more often in non-White individuals, often because they reside in rental properties.[100] Historically, high lead levels in rental housing prompted the USEPA to create lead regulations. The Residential Lead Based Paint Hazard Reduction Act of 1992 (Title X) requires that landlords must disclose the presence of lead in rental properties if this information is known.[101] Additionally, all public housing must be declared lead-free before occupancy.[102] This requires inspection at the local level, a process that could also be used for radon testing. Since the EPA has decided not to regulate radon at the federal level, it is up to individual states to do so

themselves. Maine is the first state to legally require landlords to test for and disclose radon levels to renters. Pennsylvania needs to do the same. Because renters are powerless to actually do anything about radon levels in their homes, it is crucial that landlords be required to test their rental properties, and disclose the results of the test in the rental agreement. Ideally, installation of radon mitigation systems in their buildings should be required if radon levels are above the action level of 4 pCi/L. Ultimately, both the local and state health departments need to work with the city council of Allentown to come up with a plan to require the testing of rental properties for radon. This should include passing legislation that allocates funds for more robust radon education programs along with free testing and analysis, and requiring home inspectors of public housing to conduct routine radon testing and mitigation.

In addition, Pennsylvania policy makers need to make policies that legally require an independent certified tester to test a home at the time of a real estate transaction, and if the levels are high, then the home seller should be required to install a radon mitigation system prior to closing. The cost of the mitigation system could be negotiated at the time of sale. Policies must also be created that legally require all schools and child care centers to be tested for radon and mitigate if radon levels are elevated.

Finally, health care providers have an obligation to inform patients about the high risk of radon exposure to residents of Allentown and the greater Lehigh Valley. In both surveys, we found that while health care providers could play a key role in increasing radon awareness, they don't play a key role. State chapters of professional associations including the American Medical Association and American Academy of Pediatrics

should strongly recommend that discussions take place during office visits, and that information about the risk of radon exposure be visible and available in the office and on the practice's website. In addition, radon questions should be added to the electronic medical record questionnaires during new patient visits so that health care providers are prompted to discuss it with their patients. Medical schools should ensure that their students have a firm understanding of common environmental health exposures and their effects on human health.

5.9 Future Research

Future studies are warranted to investigate factors that may facilitate or hinder awareness of environmental health risks such as radon, especially among vulnerable populations that are disproportionately affected by these hazards. In addition, studies to determine the types of messages that might resonate with the Hispanic population could be beneficial in designing interventions and media campaigns. These messages could then be test marketed to find out which ones educate and motivate people to test their homes. A larger study of health care providers could lead to better understanding of the challenges and limitations they encounter when communicating environmental risk and treating a large ethnic population such as the one in Allentown, PA, and to determine ways that radon risk information could best be integrated in routine patient visits. This might involve reaching out to representatives of local and state chapters of organizations of the American Academy of Pediatrics and the American Medical Association. It could

be useful to collaborate with the American Lung Association and other national, state, and local entities to strategize ways to encourage health care providers to get on board and start discussing radon with patients.

5.10 Conclusion

The majority of the Hispanic population that we surveyed had never heard of radon. In addition, of those that had heard of radon, the majority of both the Hispanic and non-Hispanic population did not know that they lived in an area with very high levels. Health communicators may need to consider ethnicity and culture when designing messages regarding radon risk in order to educate and better inform the public.

Most of the sample population used the Internet or their health care provider to learn about health-related topics, yet only 5% reported that they had ever heard of radon from their health care provider. Of the health care providers we surveyed, only 5% (2 out of 40) indicated that they had ever discussed radon with their patients. Health care providers must educate their patients about the risk of radon exposure and its link to lung cancer.

Policies regarding radon need to be created in Pennsylvania. Most of the respondents in the sample population who had heard of radon were homeowners who had heard of radon from their realtors, which leaves renters at a disadvantage. New policies that require landlords to test their rental properties for radon need to be developed and implemented in Allentown in order to minimize the risk of developing radon-related lung cancer. In addition, radon testing and mitigation (if needed) should be legally required at

the time of any real estate transaction. Finally, radon testing and mitigation should be legally required for all schools and childcare centers in the state.

Appendix 1

Survey Questionnaire 1

Do you live in Allentown? If Yes, continue. If No, do not continue.
Are you at least 18 years of age? If Yes, continue. If No, do not continue.

1. Have you ever heard of radon?
   - ☐ Yes (Skip to Question #2)
   - ☐ No (Skip to Question #11)

2. Where have you heard about **RADON**? (Choose ALL that apply)
   - ☐ TV commercial
   - ☐ Radio commercial
   - ☐ TV program/news
   - ☐ Radio program/newsIRB
   - ☐ Newspaper/Magazine
   - ☐ Internet
   - ☐ My Doctor
   - ☐ Family/Friend
   - ☐ A realtor
   - ☐ Other_____

3. Which of the following statements about RADON is true? (check all that apply)
   - ☐ It is an invisible gas that can become trapped inside your home.
   - ☐ There is nothing that can be done to remove radon from your home.
   - ☐ You live in an area where indoor radon levels are typically very high.
   - ☐ Breathing in radon gas can cause lung cancer.

4. How aware are you of the health problems that can be associated with high **RADON** levels in your home?
   - ☐ Not aware of any associated health problems
   - ☐ Somewhat aware of associated health problems
   - ☐ Fully aware of associated health problems

5. How concerned are you about the health problems caused by **RADON** exposure?
   - ☐ Not concerned
   - ☐ Somewhat concerned
   - ☐ Very concerned

6. Have you or someone else ever tested your current residence for **RADON**?
   - ☐ Yes (Continue to Question #7)
   - ☐ No (skip to Question #10)
   - ☐ I don't know (skip to Question #10)

7. If you answered YES to #6, was the RADON level in your home found to be higher than recommended?
   - ☐ Yes it was higher than recommended (Continue to #8)
   - ☐ No it was not higher than recommended (Continue to #11)
   - ☐ I don't know what the level was (Continue to #11)

8. **If you answered YES to 7**, have you or someone else paid someone to install a **RADON** pump in your home?
   - ☐ Yes (Continue to #11)
   - ☐ No (Continue to #9)
   - ☐ I don't know (Continue to #11)

9. **If you answered NO to #8**, why wasn't a **RADON** pump installed? (Choose ALL that apply)
   - ☐ It is too expensive
   - ☐ You do not know how to have a radon pump installed
   - ☐ You do not own your home
   - ☐ You do not believe that radon is a health threat to you or to your family.
   - ☐ You found other ways to take care of the problem
   - ☐ There was already a pump installed when you moved in
   - ☐ You don't know.
   - ☐ Other:_____

10. **If you answered NO or I don't know to #6,** why have you not tested your home for **RADON**? (choose all that apply)
   - ☐ You do not know how to test for radon.
   - ☐ You do not believe that radon is a health threat to you or to your family.
   - ☐ Testing is too expensive.
   - ☐ You do not own your own home
   - . ☐ There is already a radon pump in your home
   - ☐ You don't know.
   - ☐ Other:_____

****

11. Are you?
    - ☐ Male
    - ☐ Female
    - ☐ Refused

12. Is your age between?
    - ☐ 18 and 35
    - ☐ 36 and 50
    - ☐ 51 and 65
    - ☐ Over 65

13. What is your highest level of education?
    - ☐ Less than high school
    - ☐ High School graduate
    - ☐ 2-4 years of college
    - ☐ Refused

14. Are you of Hispanic/Latino or Spanish origin?
    - ☐ Yes
    - ☐ No
    - ☐ Refused

15. What language do you most often speak at home?
    - ☐ Spanish
    - ☐ English
    - ☐ Other_____

16. What zip code do you live in?
    - ☐ 18101
    - ☐ 18102
    - ☐ 18103
    - ☐ 18104
    - ☐ Other:_____

17. What type of housing do you live in?
    - ☐ Apartment/Rental
    - ☐ House/Rental
    - ☐ House/Owner
    - ☐ Condo/Owner
    - ☐ Condo/Rental
    - ☐ Other_____

18. How many years have you lived at your current address?
- ☐ Less than 5
- ☐ 5-10
- ☐ 11-15
- ☐ 16-20
- ☐ more than 20

19. How many years have you lived in Allentown?
- ☐ Less than 5
- ☐ 5-10
- ☐ 11-15
- ☐ 16-20
- ☐ more than 20

20. How many children under 18 live in your home?
- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ more than 5
- ☐ Refuse

21. Including yourself, how many adults, aged 18 and over, live in your home?
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ More than 5

22. Which best describes the total combined annual household income?
- ☐ Less than $10,000 per year
- ☐ $10,000 to less than 25,000 per year
- ☐ $25,000 to less than 50,000 per year
- ☐ $50,000 to less than 75,000 per year
- ☐ Over $75,000
- ☐ Refuse

23. The most recent time you looked for information about health or medical topics, where did you look first? (Choose only one).
- ☐ Books
- ☐ Brochures/Pamphlets
- ☐ Public Health Organization (such as the Allentown Health Bureau)
- ☐ Doctor or health care provider
- ☐ Internet
- ☐ Newspaper
- ☐ Magazine
- ☐ TV
- ☐ Radio
- ☐ Family/Friends
- ☐ Church
- ☐ I don't look for health information
- ☐ Other_____

24. Have you smoked at least 100 cigarettes (tobacco) in your entire life?
- ☐ Yes
- ☐ No
- ☐ Don't know
- ☐ Refused

25. Do you now smoke (tobacco) everyday, some days, or not at all?
- ☐ Every day
- ☐ Some days
- ☐ Not at all
- ☐ Refused

26. Do you currently live with smokers (tobacco)?
- ☐ Yes
- ☐ No
- ☐ Refused

27. In the past 12 months, how many times have you visited a doctor or other health care professional?
- ☐ Never
- ☐ Once
- ☐ More than once
- ☐ Refused

28. Has a doctor ever discussed the health effects of LEAD poisoning with you?
- ☐ Yes
- ☐ No
- ☐ Don't know
- ☐ Refused

29. If you have taken a child under the age of 5 to a doctor in the past 12 months, has the doctor ever discussed the health effects of LEAD poisoning on children with you during that visit?
- ☐ Yes
- ☐ No
- ☐ I have not taken any children to the doctor in the past 12 months
- ☐ Don't know
- ☐ Refused

Thank you for completing this survey.

Appendix 2
Physicians Information Survey

1. Which best describes your job title?
   ___Pediatrician
   ___Family Physician
   ___Physician's Assistant (Pediatric Practice)
   ___Physician's Assistant (Family Practice)
   ___Nurse Practitioner (Pediatric Practice)
   ___Nurse Practitioner (Family Practice)
   ___Other (specialty)_____

2. Do you discuss or inform your patients about ***lead*** toxicity?
   ___Always
   ___Sometimes
   ___Never

3. Do you provide ***radon*** risk information for your patients?
   ___Always (continue to number 4)
   ___Sometimes (continue to number 4)
   ___Never (skip to number 6)

4. If *Always* or *Sometimes* to #3, how are you communicating ***radon*** risk? Check all that apply.
   ___Verbally
   ___Brochures
   ___Posters
   ___Websites
   ___Other (please specify) _____

5. If *Always* or *Sometimes* to #3, in what language is this information available?
   ___English
   ___Spanish
   ___Both English and Spanish
   ___Other (please specify) _____

6. If *Never* to #3, please indicate the reasons why you are not providing information on ***radon*** risk. **Check all that apply**.
   ___I am not required to inform my patients about radon
   ___I have limited knowledge of radon risk
   ___I do not consider radon a risk
   ___I do not have enough time during patient visits to discuss radon risk
   ___I do not have enough informational resources about radon to share with my patients
   ___I do not want to alarm my patients
   ___My patients already receive enough information
   ___Other (please specify) _____
7. If brochures and posters about ***radon*** were provided to you for your practice, would you consider displaying them?
   ___Yes
   ___No

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Education

- Doctorate, Public Health, Johns Hopkins Bloomberg School of Public Health Baltimore, MD (2017)
  Dissertation Title: *Examination of Knowledge, Attitudes and Beliefs Regarding Radon*

- Master of Public Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD (2009)

- Master of Science in Biology, New Mexico State University, Las Cruces, NM (1989)

- Bachelor of Science in Medical Technology, University of New Hampshire, Durham, NH (1982); Board Certified Medical Technologist (ASCP)

- Pennsylvania Teacher Certification in Biology (Grades 7-12)

Teaching Experience

Muhlenberg College, 1994-present, Lecturer in Biology and Public Health

Biology Department, 1994-2015
- Principles of Biology
- Concepts of Biology: Human Biology
- Concepts of Biology in Practice
- Applied Physiology
- Microbiology
- Biochemistry Lab

Public Health 2007- present
- Issues in Public Health
- Environmental Health
- Social Justice and Public Health in Botswana
- Public Health Practice in Panama
- Occupational Health
- Infectious Disease Epidemiology

First Year Seminar
- A World Out of Balance

Clusters

Business and Public Health
Health, Behavior and Society

Administrative Experience (2017)

Director, Public Health Program, 2010- present
Chair, Curriculum Committee, 2016-present

Recent Research projects with students

Spring 2016
Attitudes and Beliefs About e-cigarettes on Muhlenberg's Campus
Summer 2016
Medical Amnesty and Underage Drinking
Fall 2015- present
Knowledge of Radon in a Latino Population
Fall 2014-Spring 2015
What's on Your Chicken? A study of Campylobacter prevalence
Summer 2017-Fall 2017
Developing a Smoke-Free Policy for Muhlenberg College

Grants (2017)

Faculty Center for Teaching Course Development Grant, Summer 2017
Public Health Summer Research Grant, Summer 2017
Harry C. Trexler Trust Grant for student-faculty research (AY 2016-2018)

Professional Memberships

2010- present American Public Health Association (APHA)